A4PS-MS-D

PRINCETON UNIVERSITY

Department of Astrophysical Sciences

Final Report

Contract NAS-8-27687

Stratoscope II Integrating Television Camera

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Supported By The

National Aeronautics and Space Administration

Marshall Space Flight Center
Huntsville, Alabama

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SUMMARY

On June 19, 1971 Princeton University Observatory received a contract from NASA-MSFC for the development, construction, test and delivery of an integrating television camera for Stratoscope II. This camera was to replace the 70 mm photographic film camera as the primary data sensor on Flight 9 of Stratoscope, which was subsequently cancelled.

The television camera has been completed, and is being used for laboratory tests to develop optimum means of calibration and data processing of the video signals from these types of television sensors which are expected to play a major role in the LST and most future astronomy programs, both in space and terrestrial. The television camera will also be used for ground based observations on the Princeton 36" telescope.

This final report includes the system block diagrams. The electrical schematics and mechanical drawings are available at Princeton. Performance data is included as well as a definition of the interface with the telescope, power, telemetry, and communication systems. Photographs of the hardware, Figures 2 through 6, show the two major subassemblies, the electronics and the camera head. The workmanship on the hardware is quite good, with the wiring and assembly being done by NASA certified wiremen. Figure 7 is a photograph of a typical circuit board.

While the design constraints for a satellite borne system are different from those for a balloon payload, much of the design in this Stratoscope television camera will be useful in the design of similar systems for LST.

STATEMENT OF DESIGN REQUIREMENTS AND MISSION

The Stratoscope II balloon-borne 36-inch telescope was designed to provide nearly diffraction limited imagery in the visible region of the spectrum. In many cases this very high resolution results in low flux levels per picture element. This in turn requires long exposure times to achieve an adequate signal-to-noise ratio in the data. The television system employs a photocathode whose quantum efficiency is more than a factor of ten higher than the quantum efficiency of photographic film. That is, the exposure time with the television system is one-tenth that required with the photographic film camera used in earlier Stratoscope II flights.

Another important advantage of a television system in a mission such as a balloon flight is the real time feedback to the ground of the results during the flight. This makes possible more accurate in-flight adjustment of the focus, alignment and exposure times; and more efficient use of the time aloft, since several exposures of the same object are not required to insure an optimum exposure.

The basic design requirement was to replace the 70 mm photographic camera working at f/100 with an integrating television camera working at f/200. The longer focal length was selected to optimize the match of the MTF of the television sensor to the optical system MTF. This reduced the field of view but did not reduce the sensitivity.

The mechanical and electrical design was based on a similar television system being built at the same time for a sounding rocket payload. This resulted in a considerable cost advantage. For the sounding rocket payload, weight was at a premium, while power consumption was relatively unimportant for its short flight. In a balloon flight the battery weight and heat from the power dissipation is more important. In this respect the camera that was built is not optimized for a balloon mission. Decreasing the power consumption would have involved a heavier focus coil and camera head housing. In some circuits, such as the Logic, low power active components would have been selected in an optimum balloon design.

The camera head is designed to be pressurized to avoid high voltage arching at high altitude. All camera voltages greater than twice the power supply battery voltage of 28 volts are generated and contained within the camera head.

The camera system is self-sufficient in that it generates its own timing signals and requires only raw power to operate.

Telemetry is provided to monitor the system performance. The camera can be commanded from the ground to initiate exposure, readout, etc.

In the following section the detailed block diagram is presented along with the interface specification.

SYSTEM DESCRIPTION

The integrating television system operates in a sequential mode consisting of PREPARE, EXPOSE, and READ. This sequence is controlled by the electronic timing logic in the television camera and can be initiated by ground command.

Figure 9 shows the video waveform and timing for the video part of the system. The frame rate is 12.5 seconds per frame; the line rate is 60 lines per second and the video bandwidth is 20 kHz. The composite video includes a 61.44 kHz subcarrier that allows the analog to digital conversion of the video on the ground to be accurately synchronized on a picture element basis. The detailed timing and amplitude data for the composite video waveform, including sync, is given in Figure 9.

SEC Sensor

The SEC vidicon tube developed for the astronomy application and used in the SS II camera is the Westinghouse WX-31718. The tube employs magnetic focusing for both the reading and image sections. Since there are several more compact types of SEC tubes available, an explanation of why the WX-31718 is considered to be the optimum among the available types, is in order.

A major consideration is the size of the SEC storage target. For example, the diffraction limited imagery application requires that the sensor be used with a sufficiently long focal ratio so that the image tube's MTF does not significantly degrade the overall MTF. By choosing the focal ratio so that the telescope MTF is zero at the spatial frequency where the sensor MTF has dropped to 0.5, the overall MTF is not seriously degraded by the sensor. For the SEC tube this occurs at about 10 cycles per mm spatial frequency at the target. The larger the target, the more half cycles or image elements can be included in the field of a given exposure. The 25 mm square targets of the WX-31718 provide a field of 500 x 500 image elements at the 10 cycles per mm limit. This is comparable in field coverage at equal MTF to a photographic film (e.g., 103 AG) 12 mm square. For many astronomical objects such as image field is adequate. It would require additional exposures to record objects or fields larger than 25 arc sec with a one-meter diffraction limited telescope. For ground based observations where the seeing is rarely better than one arc second, the field coverage is about 8 arc minutes.

Another parameter related to target size is photoelectron storage capacity, on a per element basis. A 50 micron square image element in the WX-31718 target (corresponding to operating with spatial frequencies up to 10 cycles per mm) has a storage capacity of about 2500 photoelectrons, which corresponds to a limiting photometric accuracy of two percent rms.

The per element photometric accuracy attainable in a single exposure depends on the storage capacity of the target on a per element basis. High accuracy photometry demands large target storage elements, or, alternatively, addition of successive "full target" exposures outside the camera tube.

Certain aberrations in television tube performance can be neglected or readily calibrated out if the image element size is of the order of 50 microns. An example is "beam pulling", which is a displacement of the low velocity scanning beam by the potential gradient associated with the localized charge of the image.

Attempting to use television tubes at element sizes of 15 to 20 microns simply because the tubes have some response at the correspondingly high spatial frequencies leads to a cascading of problems such as low per element photoelectron storage, low MTF values, and aberrations such as beam pulling. The conclusion is that pushing the TV tube resolution rapidly degrades its system effectiveness in the astronomical application, where most effective use of the light gathered by the telescope is the major consideration.

Another consideration in the selection of the WX-31718 tube type is that its magnetically focused image section has far superior point spread characteristics and resolution compared to an electrostatic image section. The magnetic image section also provides a flat input window which facilitates the system optical design and simplifies the attainment of a uv transmitting window.

A major advance in the SEC development program for astronomy applications was the removal of the suppressor mesh from the tube design. For many non-astronomy applications the suppressor mesh has been a necessary device to prevent destruction of the SEC target by "crossover", a destructive situation usually caused by overexposure of the tube leading to secondary emission charging of the scanned surface of the target to a potential sufficient to rupture the fragile insulating membrane. This is usually avoided by having the low potential suppressor mesh near the scanned surface of the target to limit the maximum potential the target surface can attain during a "crossover" situation.

The sequential operation of the tube in the astronomy application permits operating without the suppressor mesh. The sequential operation employed is safe because the scanning beam is off when the photocathode is operating. There are no scanning electrons to generate secondaries at the scanned surface even if a portion is being overexposed by photoelectrons. The mesh behind the target, which in the case of a tube without a suppressor mesh is the field mesh, is kept at zero potential during exposure, so that secondaries generated by primary photoelectrons cannot cause charging of the exit surface.

The scanned surface of the SEC target of the WX-31718 has a very light gold coating which prevents reading beam induced crossover of image regions that had been overexposed to saturation during the exposure mode.

Three significant benefits are realized by removing the suppressor mesh. First, the threshold noise performance is helped considerably by the reduction in the shunt capacitance of the target to ground. Second, the MTF of the tube is improved considerably. We typically obtain 80 percent modulation at 10 square wave cycles per mm without the suppressor mesh, as opposed to 40 percent with the suppressor mesh. Third, the problem of microphonic noise signals, which can be severe with slow scan readout operation, is alleviated by removal of the suppressor mesh.

Sequential Operation

For the astronomy application, where exposure times of the order of minutes and hours are common, the SEC tube is operated in a manner quite different from that employed in broadcast television operation.

In normal TV operation the image section of the SEC tube is continuously writing an image into the SEC storage target while the reading electron gun is continuously reading out the image that has been integrated in the brief frame or field interval since the beam last scanned its present location.

In the sequential operating modes used in the astronomy application the SEC tube is cycled through five modes. They are: PREPARE, EXPOSE, HOLD, READY, and READOUT.

In the PREPARE mode any residual image is erased and the SEC storage target is normalized to make it suitable for a new exposure.

During the EXPOSE mode the photocathode and image section voltages are ON, integrating the incoming image into the SEC storage target. The field mesh voltage is ZERO, which limits the maximum target voltage excursion to the target bias level.

After an exposure the tube can be put into the HOLD mode where the photocathode and image section are OFF, the reading electron gun is OFF, and the field mesh voltage is low. The integrated image stored in the SEC target will not degrade perceptibly after as many as 50 hours of storage. This mode is a safe standby mode.

The READY mode is the mode used prior to readout, to allow the wall, mesh, and target electrodes to be switched and settle to their readout levels.

During the READOUT mode the stored image is scanned out by the reading section's electron gun. During READOUT the photocathode voltage is OFF. It is safe to have a high field mesh potential during READOUT. The resultant high reading beam decelerating field contributes greatly to the high MTF and low beam pulling characteristics of suppressor meshless tubes.

The PREPARE mode is a sequence of operating states for the dual purpose of erasing any residual image including buried change patterns within the target layer, and establishing the proper target conditions for the next exposure.

The Stratoscope Integrating Television camera has two PREPARE modes, PREPARE I and PREPARE II. PREPARE I takes 2.5 minutes and PREPARE II is completed in about one fifth that time. Since the slower PREPARE I yield a somewhat more uniform image background level, it is the preferred PREPARE cycle when the two minute time difference is not significant.

The details of the PREPARE cycles and the other camera operating modes are given in Tables 1 and 2.

Another requirement of sequential tube operation is that of "target pulsing". This is a procedure in which the target bias is raised approximately 0.2 volts above that used for the final PREPARE step and for the EXPOSE mode. If this were not done, the scanning electron beam would fail to land properly on those areas of the target that have received little or no exposure. The "target pulsing" bias insures that the scanning beam will land even in those portions of the target where the exposure was zero. Although "target pulsing" insures that threshold level signals will not be compressed or lost in the readout process, it does give the video signal a rather uneven black or "zero exposure" level.

In addition to the operating camera modes used in normal astronomy applications which are ground commanded, the following modes are provided for test purposes: CONTINUOUS SCAN LOW MESH, CONTINUOUS SCAN HIGH MESH, FAST CONTINUOUS SCAN LOW MESH, FAST CONTINUOUS SCAN HIGH MESH and EXPOSURE TEST.

The CONTINUOUS SCAN modes are used for test and setup of the camera system. The low mesh mode is a safe operating mode where the target can not crossover and be destroyed. In all the continuous scan modes the photocathode image section and gun section are both simultaneously on. When operating in the high mesh mode, care must be observed that the exposure is not so intense as to cause the target to crossover.

The fast continuous modes are sixteen times faster than the normal scan rates. They are useful for quickly optimizing some camera parameters.

The EXPOSURE TEST mode is a selective readout mode where the beam reads out the target for only the first and last 5% of each active scan line.

Tables 1 and 2 contain the Camera Sequence Truth Table and the Codes for the Camera Sequence. These tables list the functional sequence of the camera's operation in its various modes.

In addition to the various commands used to operate the camera in its sequential modes, there are also commands which are used to make fine increment and decrement of key parameters during flight. These increment and decrement commands adjust the focus coil current, the photocathode voltage, and the electron beam current. The tube's electron gun heater may also be commanded on and off via ground commands.

Power Subsystem

The low voltages for the camera are supplied from a synchronized dc to dc converter and series pass regulators as shown in the Low Voltage Power Supply Block Diagram. The converter is driven at one-half the video analog to digital conversion frequency so that any power supply noise will affect each digital pixel equally and coherently, so as to be removable by digital processing. Also, the converter drive waveform is notched so that the power switching transistor that is on will be switched off before the alternate transistor turns on.

The drive circuitry also detects and limits over-current conditions in the converter. If an over-current condition persists beyond approximately 200 microseconds, the drive signal will shut off for a seven second interval. The camera input power return is transformer isolated from the camera signal return to isolate camera system ground from the power common.

All low voltages that are required for camera operations are generated in the unpressurized camera electronics package, while all the high voltage required for the tube electrodes and photocathode are generated in the pressurized camera head assembly.

The SEC electrode voltages are obtained from driven dc to dc converters as shown on the corresponding Block Diagram. These converters are also driven at one-half the A to D conversion rate.

Photocathode voltage is supplied to the tube from a regulated supply that is also driven at one-half the conversion rate. The regulator's error signal controls a dc level that is chopped and filtered before being applied to a step-up transformer and voltage multiplier filter assembly. The step-up transformer is driven with a sinewave instead of a square wave to reduce switching noise and transformer/multiplier high voltage corona.

Description of Hardware

The television tube shown in Figure 1 is an SEC-vidicon with a 25 x 25 mm target. The window of the particular tube shown has fiducial marks evaporated on the inside surface to provide geometric reference points in the image. Figure 2 shows the tube mounted in its magnetic focus and deflection coils. The video preamplifier is packaged in a small module that is mounted just behind the shoulder of the tube and in front of the deflection yoke. This is done to minimize the target lead length and the corresponding shunt capacitance to ground, thereby improving the video signal-to-noise ratio. The 8 kv photocathode high voltage power supply and the circuits for the other electrode voltages are packaged on printed circuit cards that are mounted behind the tube as shown in Figure 2. The assembly fits inside the black cylinder also shown in Figure 2 and is pressurized at slightly more than one atmosphere. The front window of the television tube forms a part of the pressure vessel. This is to minimize optical losses particularly in the ultraviolet.

Figure 3 shows the assembled camera head. The square aperture plate contains the small erase lamps for preparing the tube.

Figures 4, 5 and 6 show various views of the camera electronics. Most of the electronic components are mounted on printed circuit cards. An example is the video filter board shown in Figure 7. All boards would be conformally coated prior to flight use. Components that dissipate significant power are mounted directly to the aluminum walls of the chassis.

The weight breakdown for the camera head and electronics is listed below:

a. Electronics

1.	Electronics mechanical assembly	3991 gms	-	8.80 pounds
2.	Printed circuit cards	2730 gms	-	6.02 pounds
3.	Transformer assembly	340 gms	-	0.75 pounds
4.	Harness	272 gms	-	0.60 pounds
5.	Power components	181 gms	-	0.40 pounds
6.	Misc.	48 gms	-	0.11 pounds
		7,562 gms	-	16.68 pounds

b. Camera Head

1.	Focus coil	5669 gms	-	12.50 pounds
2.	Preamp	408 gms	-	0.90 pounds
3.	Deflection yoke	1088 gms	-	2.40 pounds
4.	Photocathode power supply	272 gms	-	0.60 pounds
5.	Head housing	3356 gms	-	7.40 pounds
6.	Tube	454 gms	-	1.00 pounds
7.	Mechanical subassemblies	1588 gms	-	3.50 pounds
8.	Erase light assembly	454 gms	-	1.00 pounds
		13,289 gms		29.30 pounds

The power dissipation of the camera is 156 watts at 30 volts supply voltage.

ELECTRICAL INTERFACE REQUIREMENTS

A. Commands

1. The following flight commands require isolated switch contact closures of 20 m sec to 100 m sec period. Only one command is required or permitted at a time.

   a. Hold
   b. Expose
   c. Prepare I
   d. Prepare II
   e. Ready
   f. Readout
   g. Exposure Test
   h. Continuous Scan
   i. Fast Continuous
   j. Army Hi Mesh Mode
   k. Continous Scan Hi Mesh
   l. Fast Continuous Scan Hi Mesh
   m. Heater On
   n. Heater Off
   o. Focus Current Increment
   p. Focus Current Decrement
   q. Beam Current Decrement
   r. Beam Current Increment
   s. Photocathode Voltage Increment
   t. Photocathode Voltage Decrement

2. The Test Console Command Circuitry is shown in Figure 8.

B. Telemetry

1. The following is a list of the telemetry channels, their minimum bandwidth and maximum noise requirements. The telemetry channels are dc coupled and the dc errors are included in the noise levels.

Channels	Noise maximum mu p-p	Bandwidth minimum Hz
a. Focus Current	5	1
b. Beam Current	50	100
c. Heater Current	50	1
d. Erase Lamp Current	500	1
e. Target Voltage	5	1
f. Frame Scan Current	50	100
g. Line Scan Current	50	100
h. Input Current	50	1
i. Input Voltage	50	1
j. Photocathode Power Supply Current	50	100
k. Sequence Status	50	10
l. Mesh Voltage	5	1
m. Photocathode Control Voltage	5	100
n. Focus Current Delta	50	1
o. Beam Current Delta	50	1
p. Photocathode Voltage Delta	50	1
q. Photocathode Temperature	50	1
r. Preamplifier Temperature	50	1
s. Electronic Box Temperature	50	1

Above based on 0 to 5 V dc telemetry channels.

C. Main Video Data Channel

1. Electrical Characteristics

a. Amplitude: from plus 1.1 to minus 1.0 volts

The Data Channel should have a unity non-inverting transfer function.

b. Frequency Response: ± 0.1 db, 0 to 70 kHz

+ 1, -3 db, 70 kHz to 100 kHz

c. Time Delay (Phase response): Peak to peak differential time delay, 0 to 70 kHz: 3 microseconds maximum.

d. Time Base Stability over 20 millisecond interval: ± 4 microseconds.

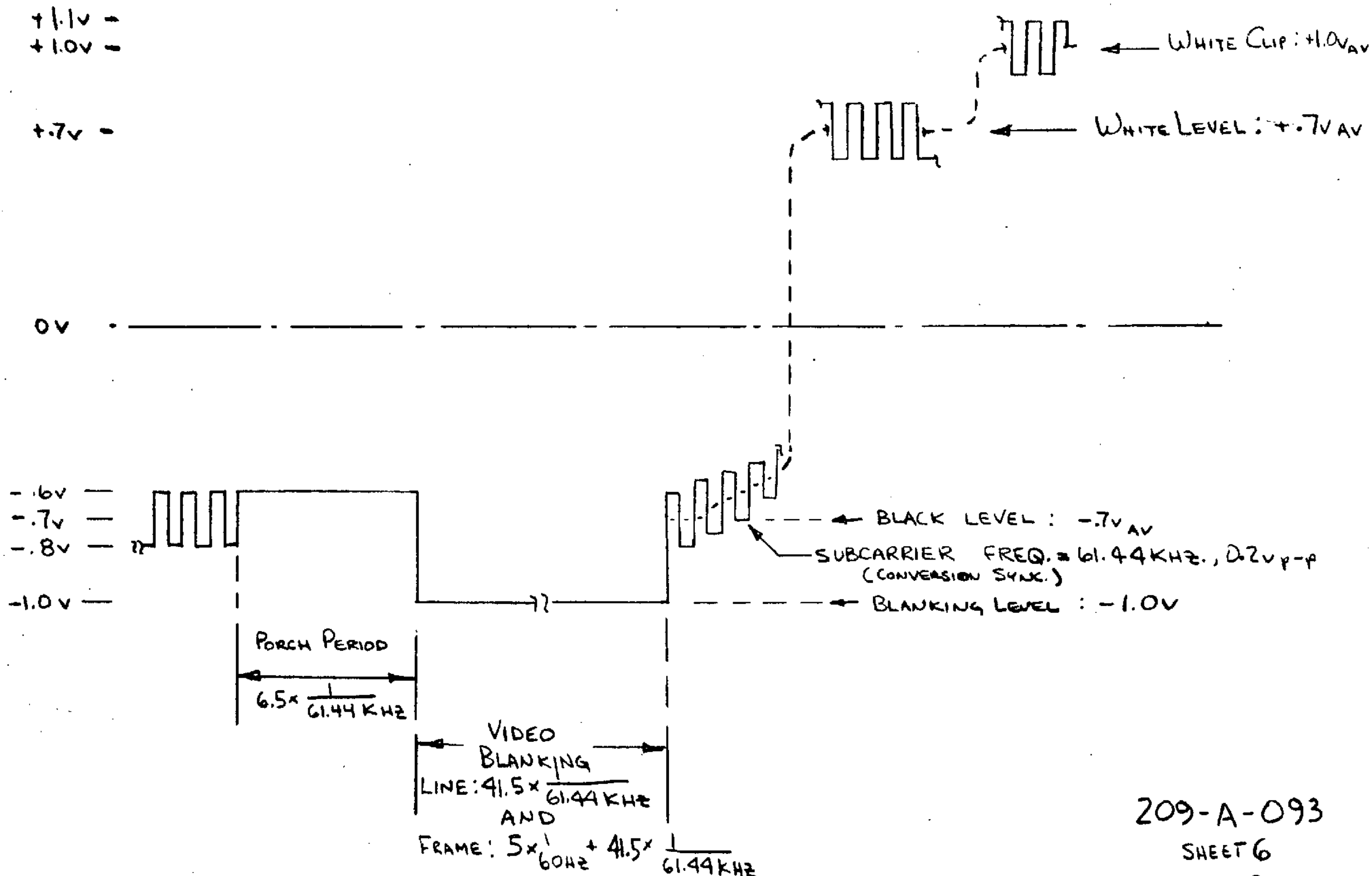
e. Channel noise (all sources including dc drifts): 0 to 100 kHz: less than 5 millivolts peak to peak.

f. Video Termination: 100 Ohm and 1000 pf in parallel.

g. Video Waveshape and Timing: see Figure 9

1. Sync Tip Level: -1.0 volts
2. Porch Level: -0.6 volts
3. Peak White Clipping Level (including conv. sync.) = +1.1 volts
4. Black Level: -0.7 volts, average
5. Conversion sync is added to video during the active line period and to a portion of the line period during frame blanking.

Figure 1 Video Waveform



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Sheet 6
Issue 3
1-20-72

B-2

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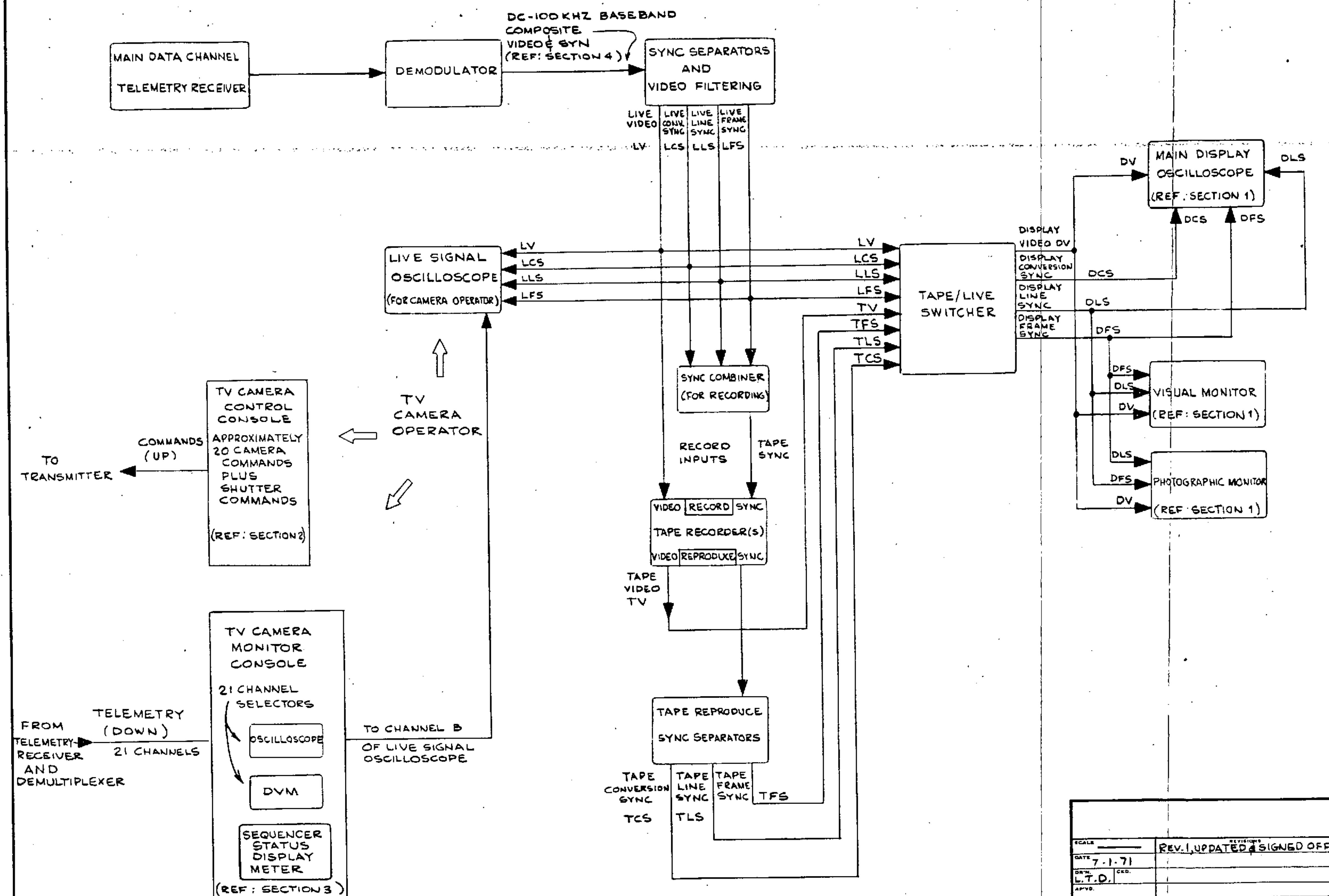

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CHARLES BRUNING CO. - FIVE HUNDRED

FOLDOUT FRAME 2

D. Camera Output Video Waveforms

The following figures show the camera video output with various test pattern inputs and both with and without the conversion sync being added.

Figure 10 - Shows a single line of video with the conversion sync added. The camera is in the Hold Mode (black level).

Figure 11 - Shows the five lines of frame blanking with the conversion sync added. The camera is in the Hold Mode.

Figure 12 & 13 - Show a single video line of a frequency test chart. Figure 12 is without the conversion sync and Figure 13 includes the conversion sync. Black-to-white video transitions can be seen on the left and right sides, and the 500 TV lines pattern appears as the frequency burst in the center of the line.

Figure 14 - Shows a single video line of a gray scale chart. The transmission of the five chart levels are 100%, 50%, 25%, 12.5% and 6.2%.

Figure 15 - Shows the digitized video output of the frequency test chart. The camera output data is digitized with 1024 image elements per line.

Figure 16 - Shows the digitized video output of the grey scale chart.

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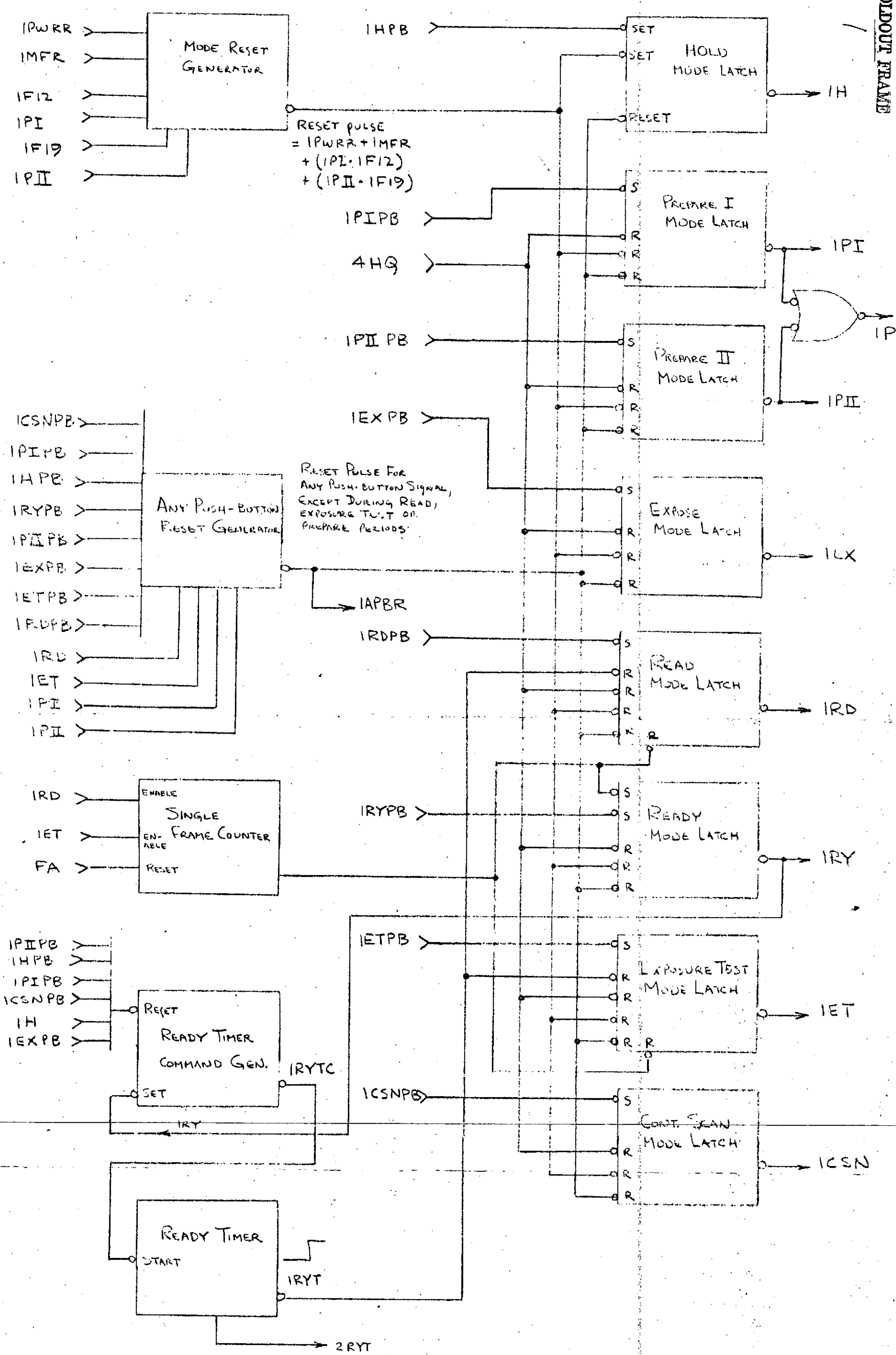

SEQUENCER — PART 1 OF 3

MODE LATCHES

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FOLDOUT FRAME

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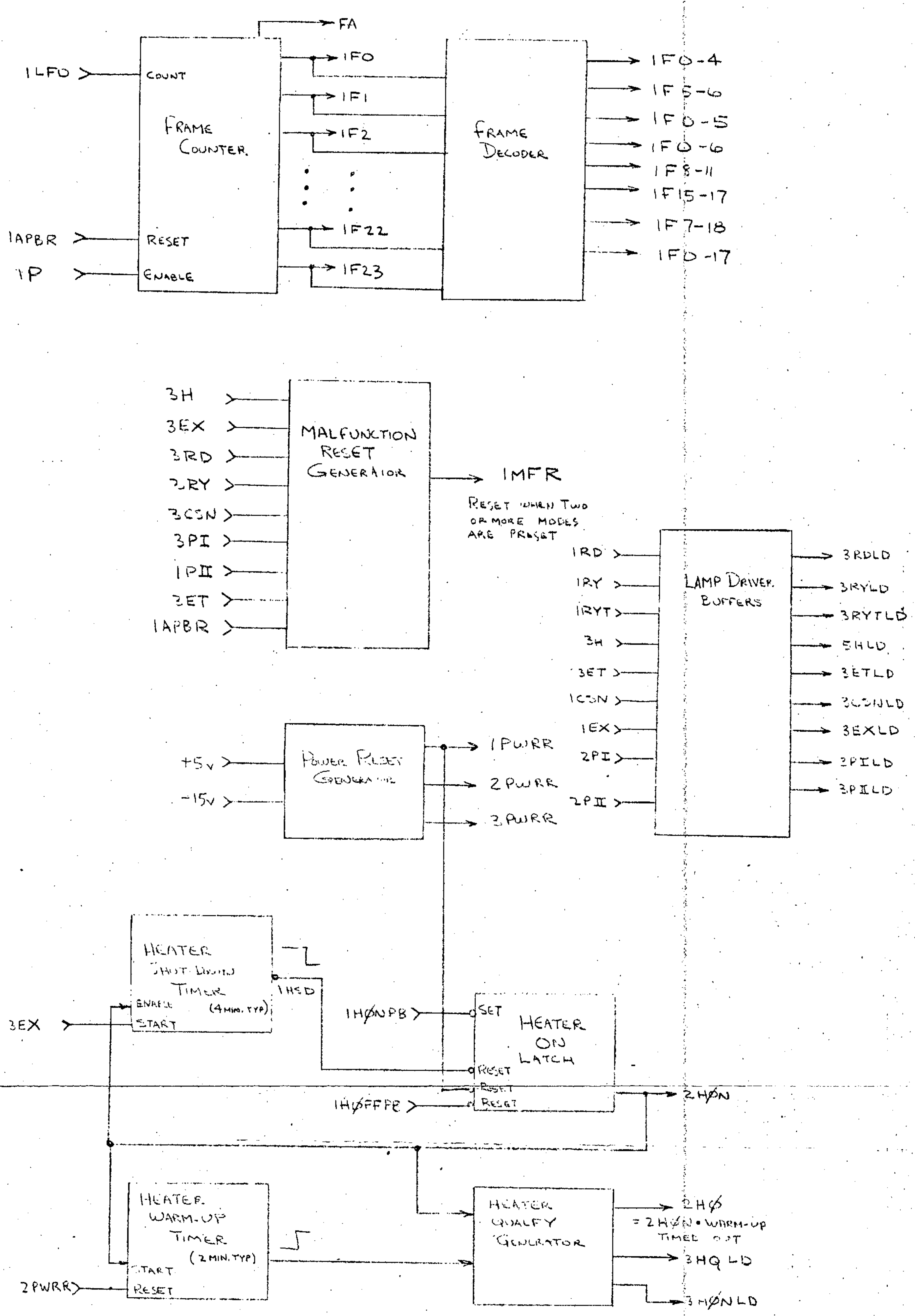

SEQUENCER - PART 2 OF 3

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FOLDOUT FRAME 2

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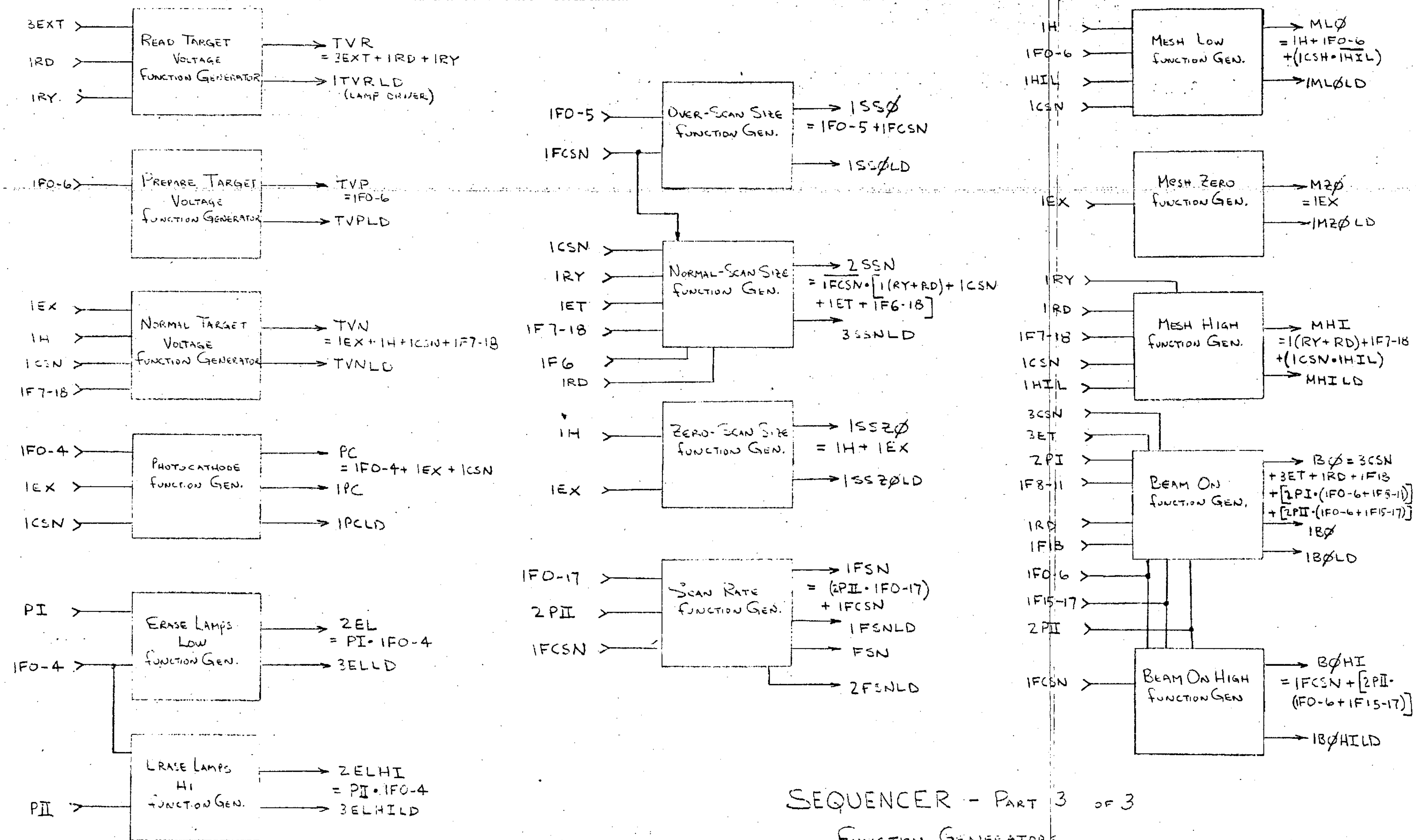

SEQUENCER - Part 3 of 3

Function Generators

12/1/...

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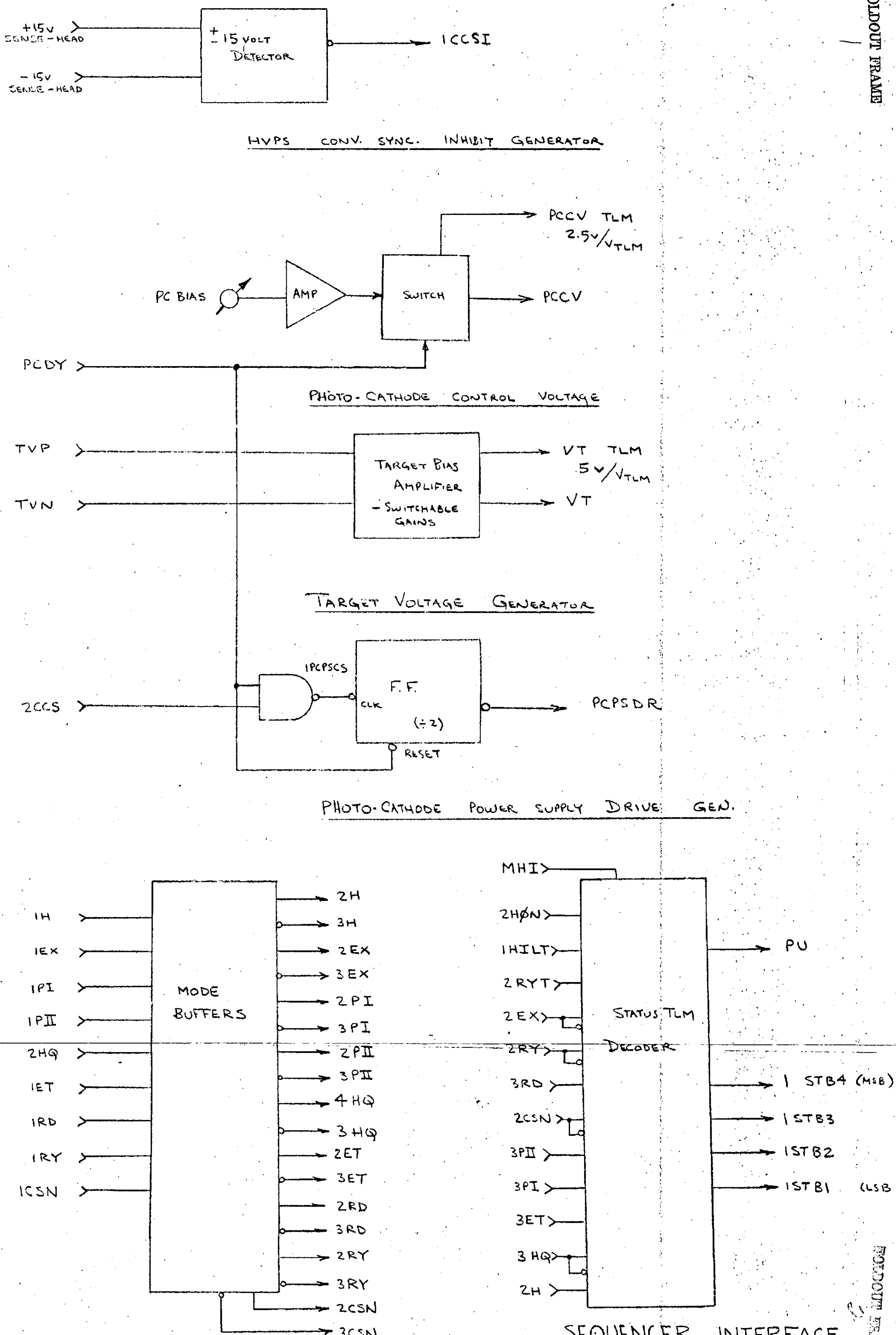

SEQUENCER INTERFACE

Part 1 of 2

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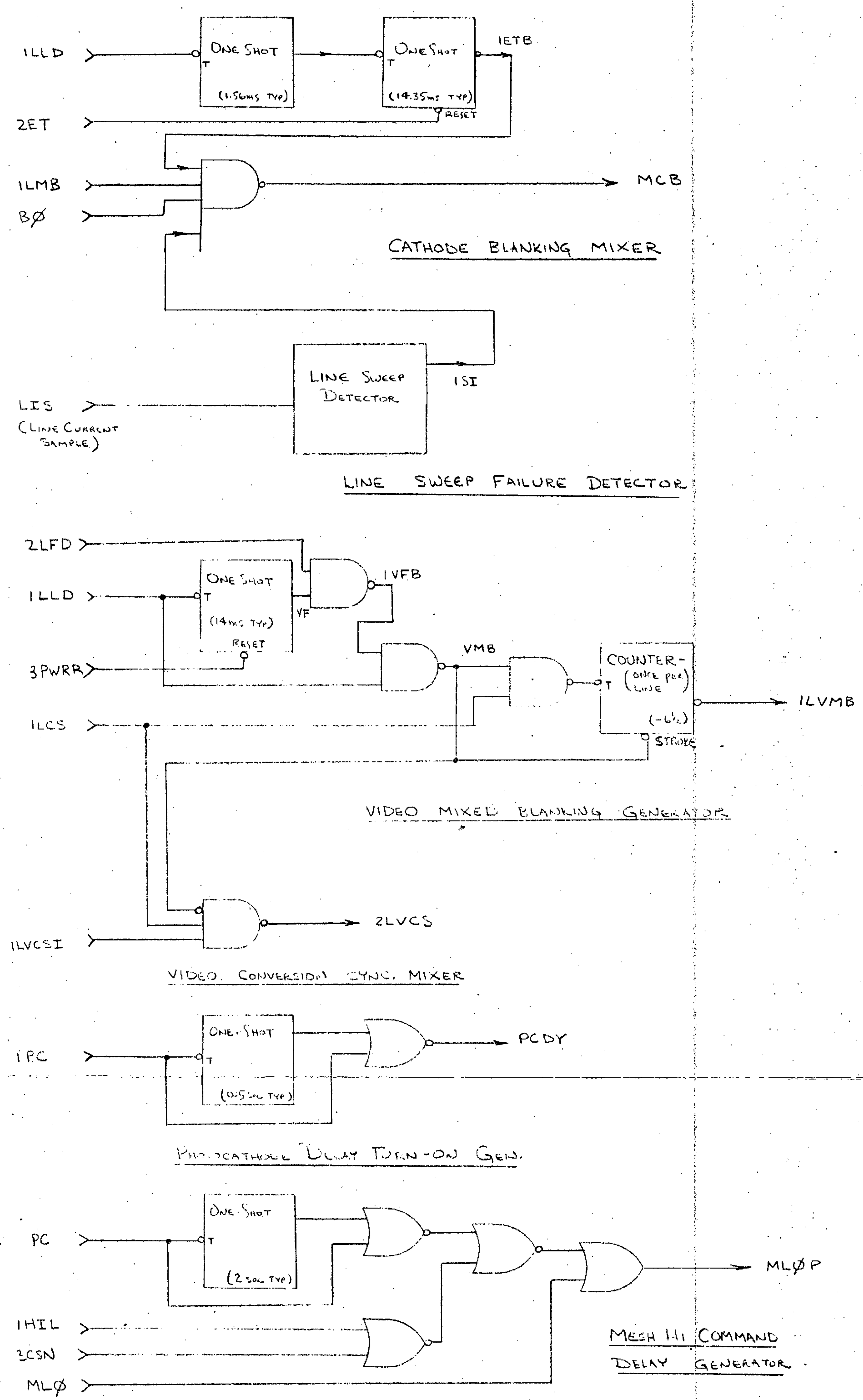

SEQUENCER INTERFACE, PART 2 OF 2

12/8/72

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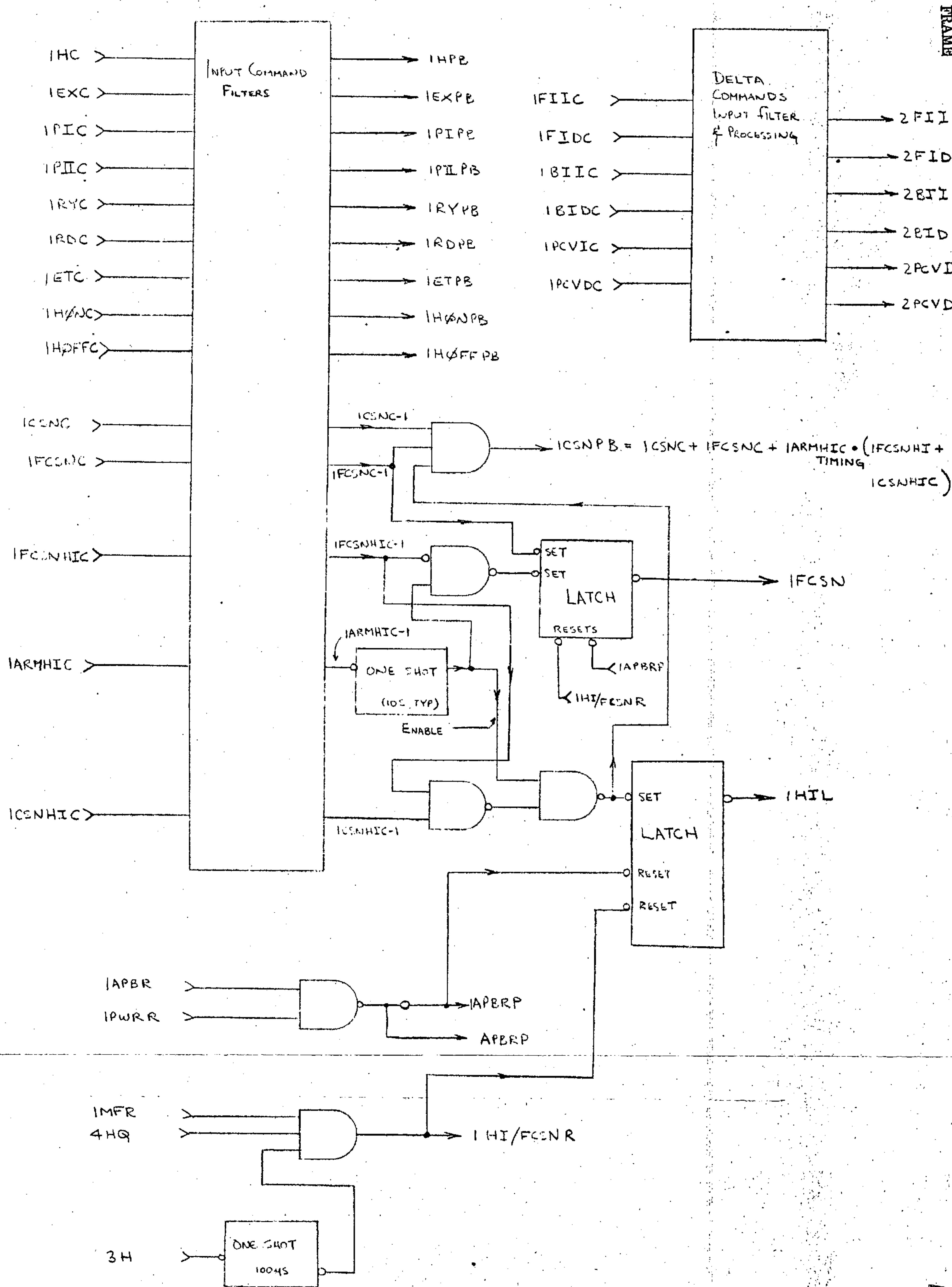

INPUT INTERFACE PROCESSER

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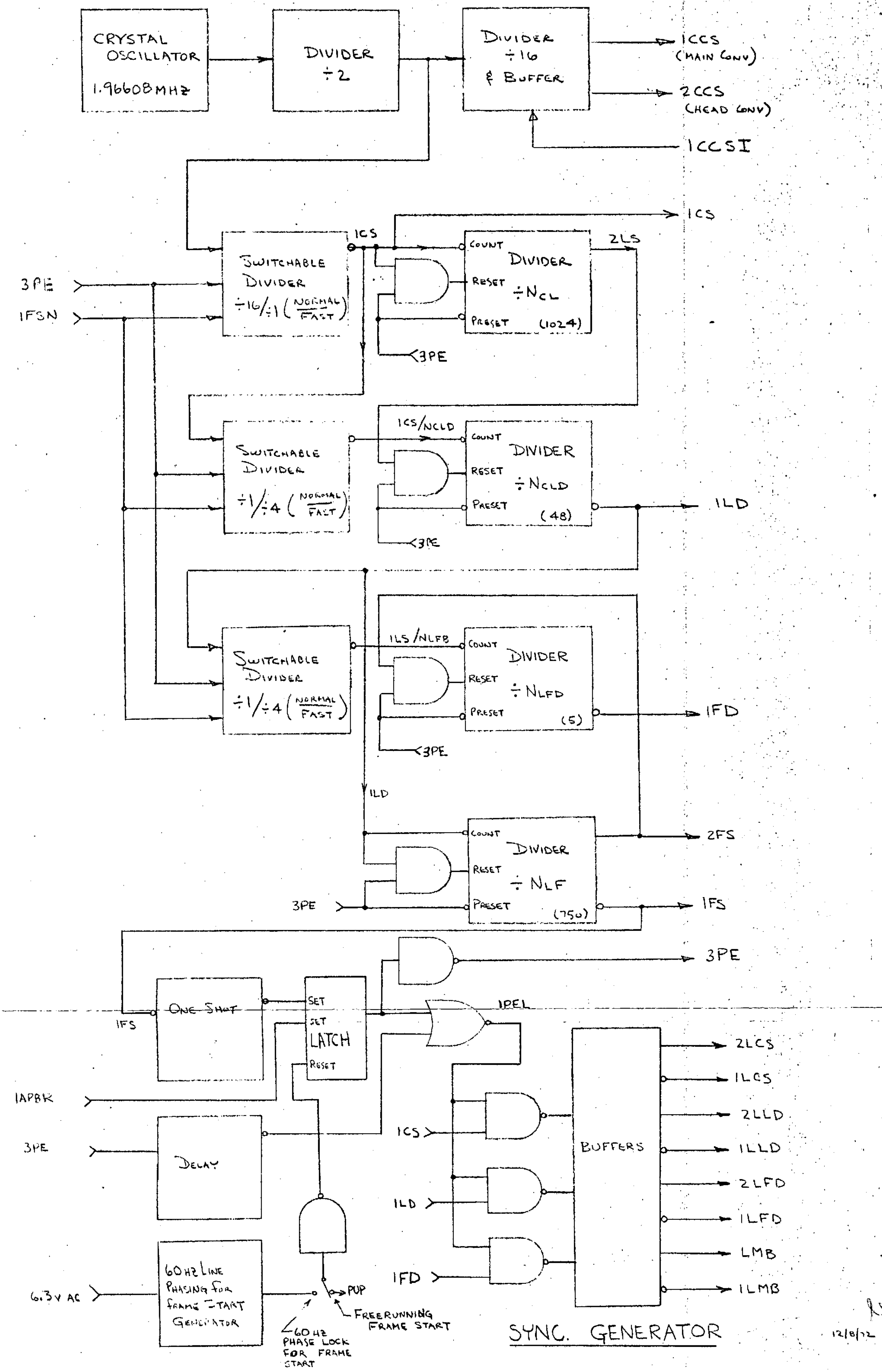

SYNC. GENERATOR

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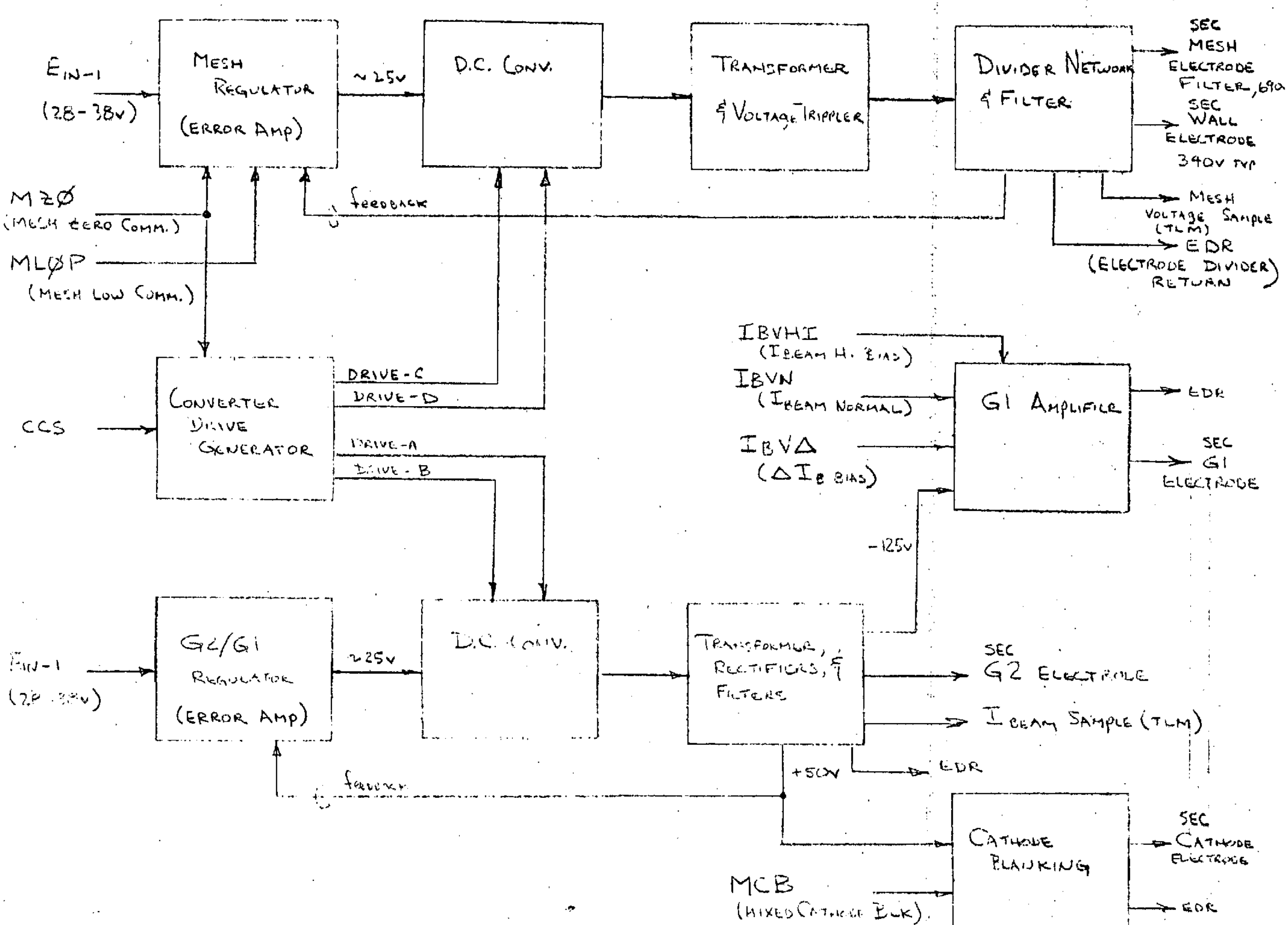
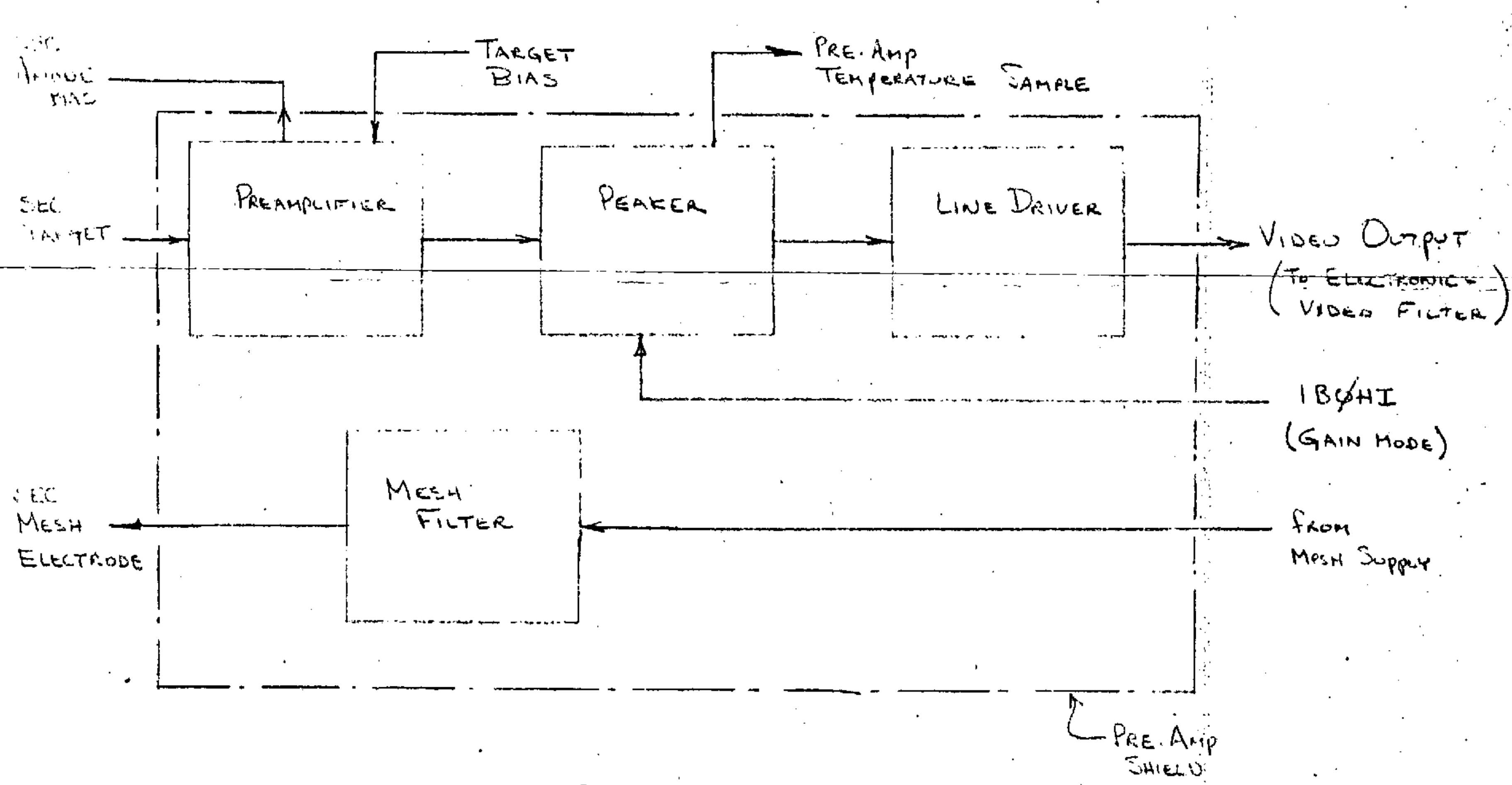


SEC ELECTRODE SUPPLIES, HVPS - CAMERA HEAD



PRE-AMPLIFIER - CAMERA HEAD

12/8/72

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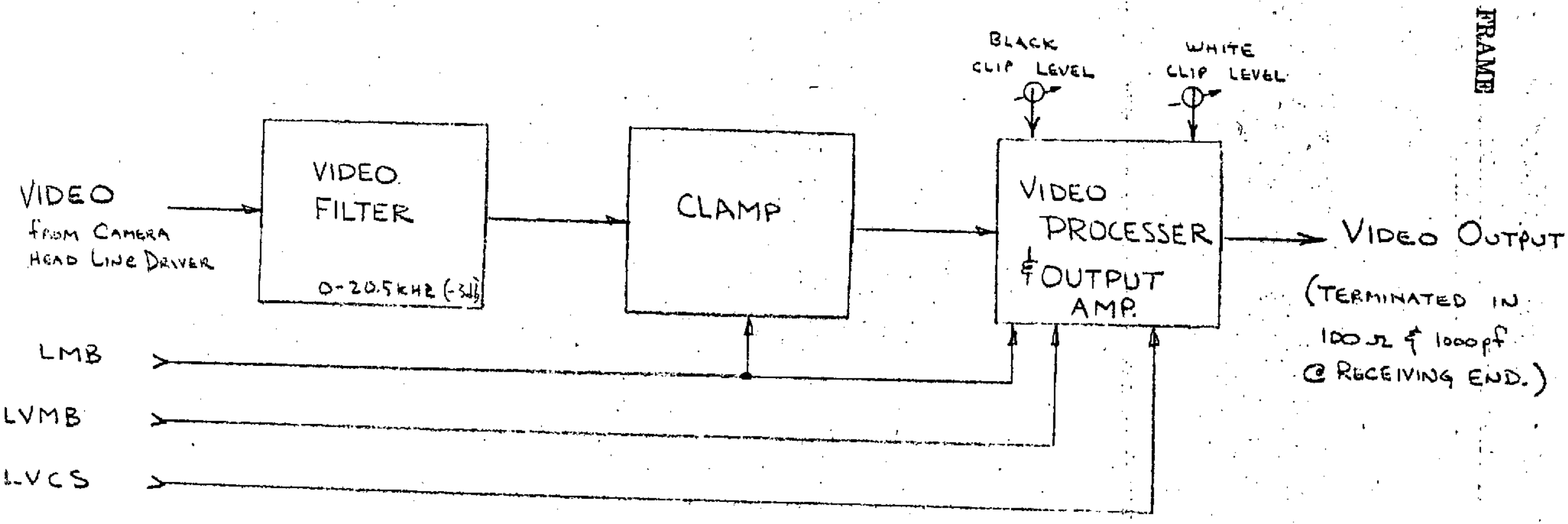
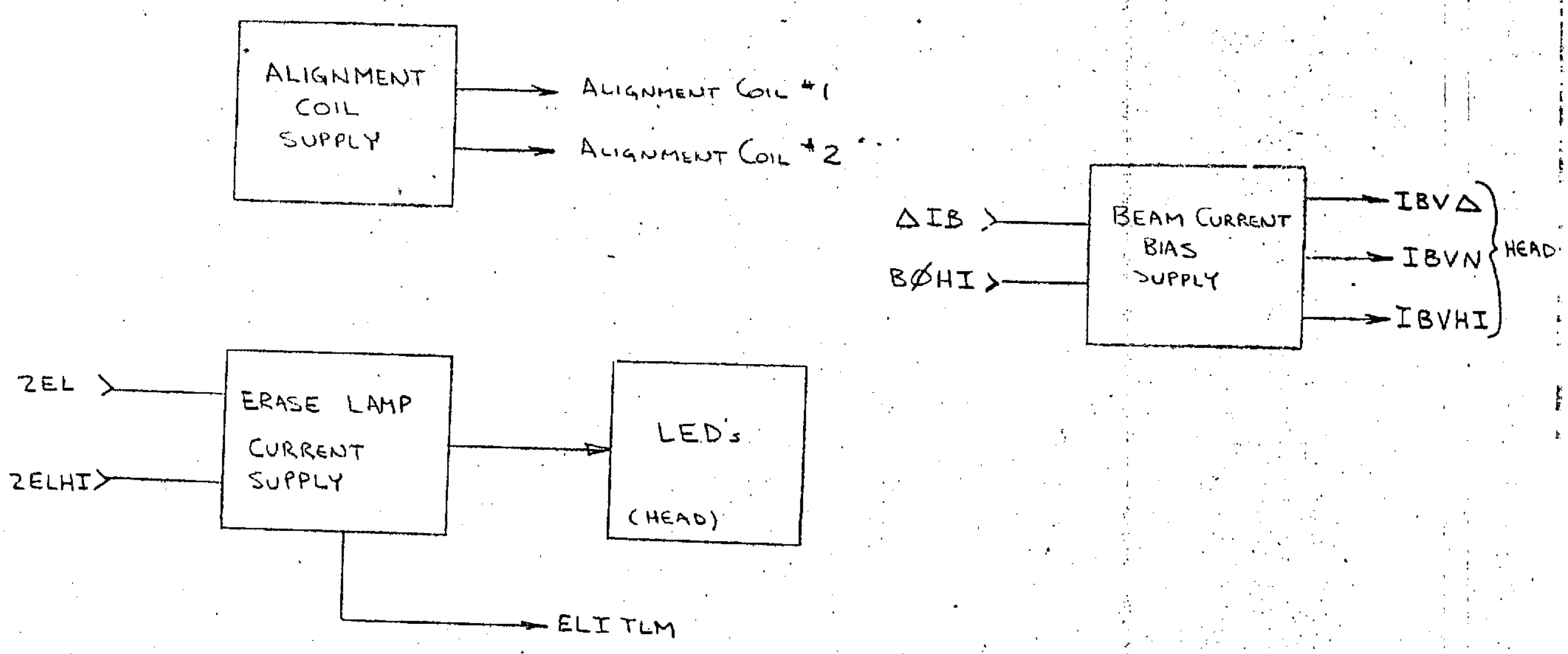


Video Amplifier



ALIGNMENT, ERASE, & BEAM SUPPLIES

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FOLDOUT FRAME

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FOLDOUT FRAME 1

FOLDOUT FRAME 2

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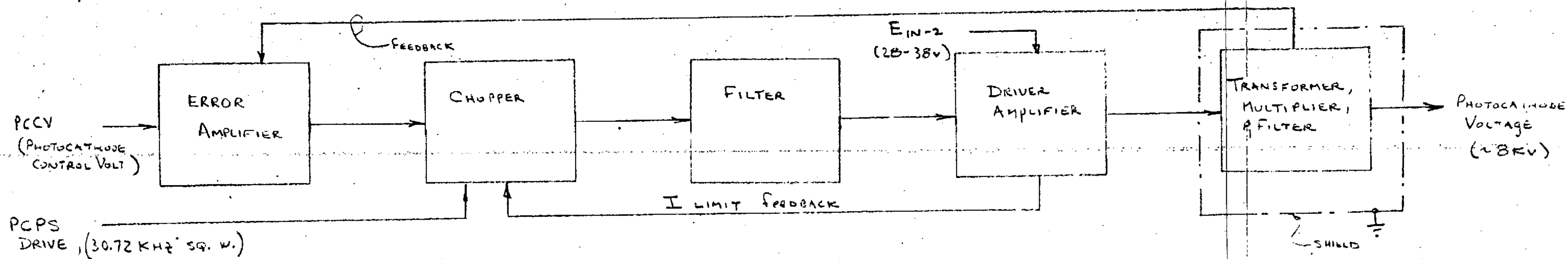

Photocathode Power Supply - Camera Head

12/4/72

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BLOCK DIAGRAM

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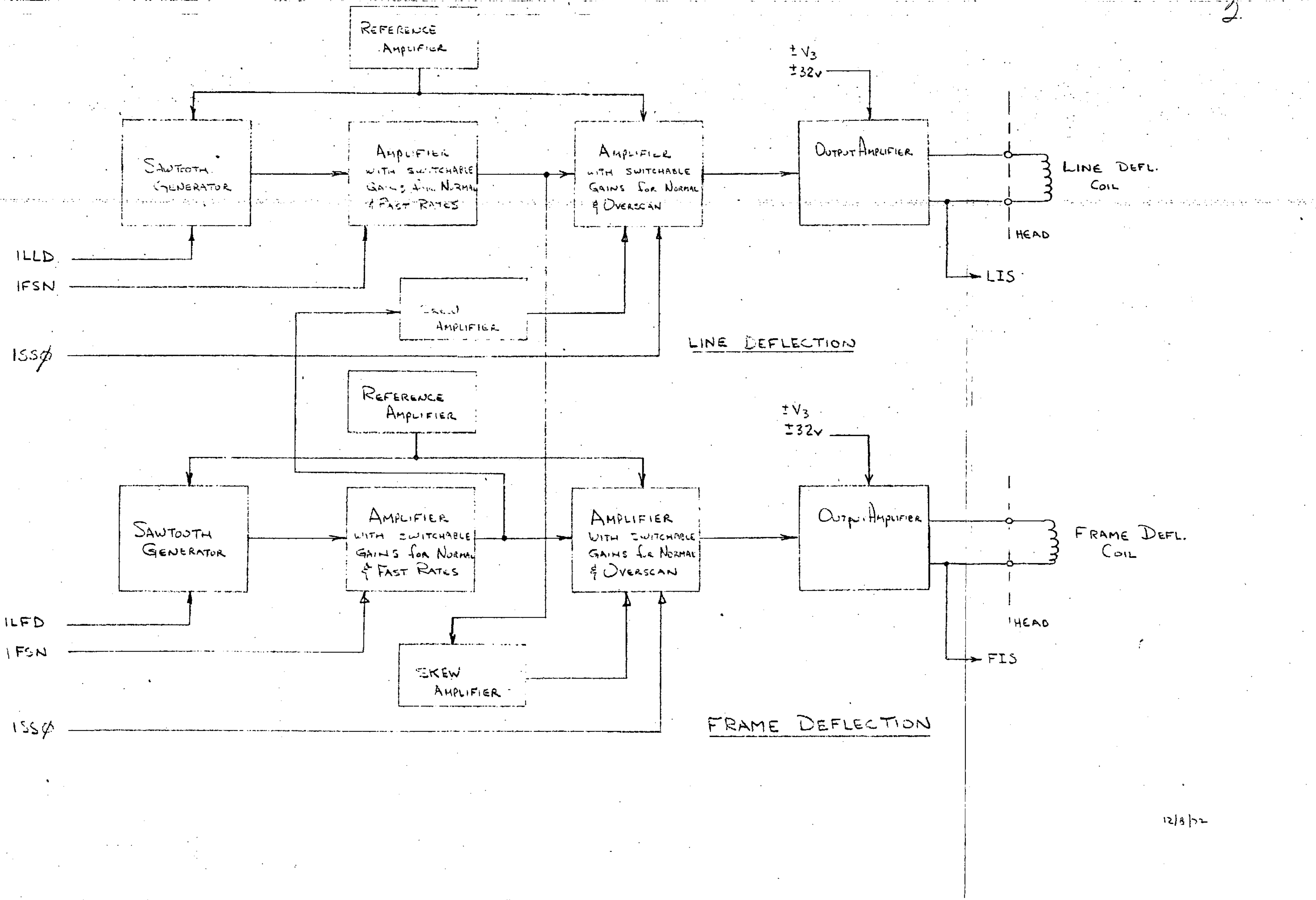

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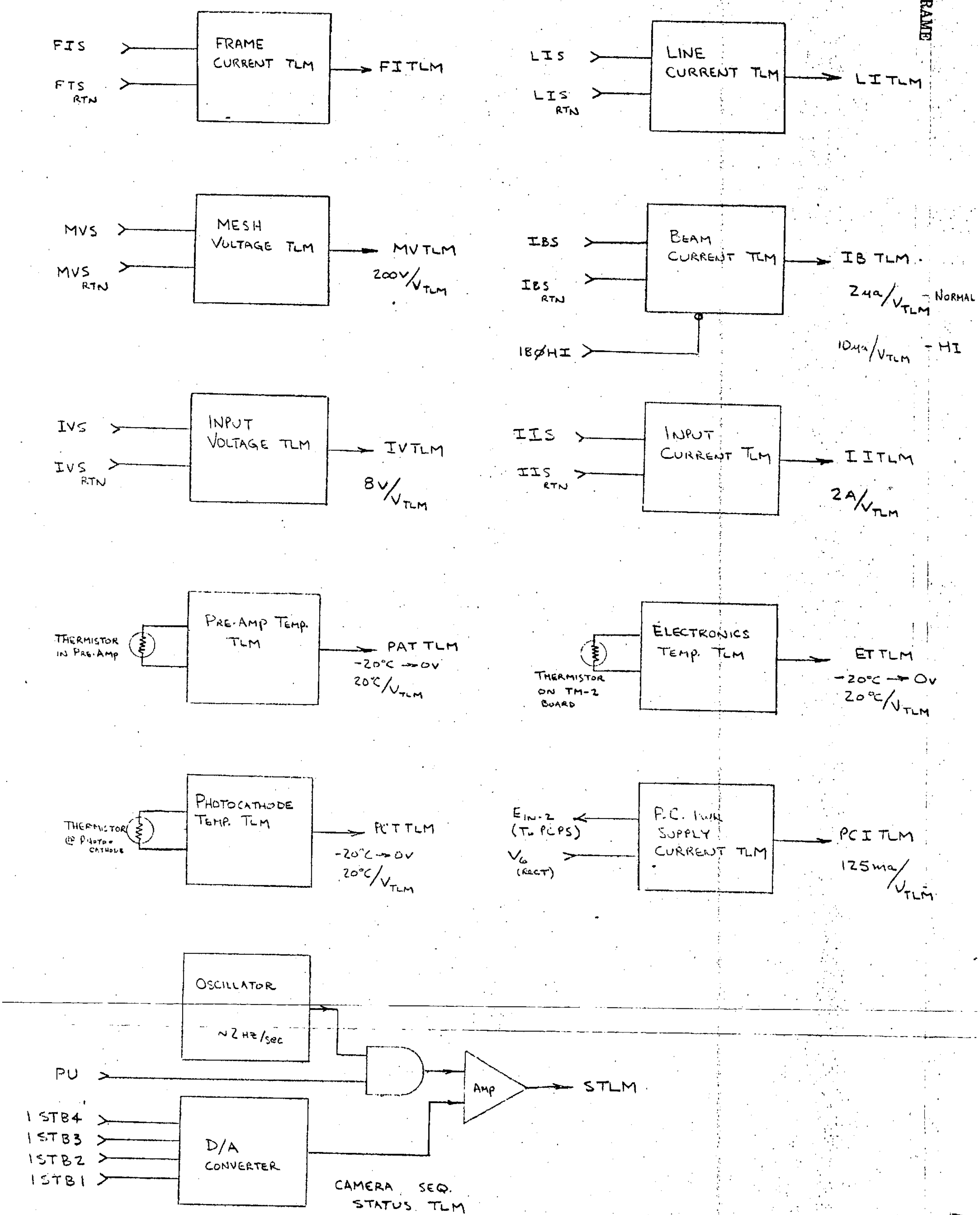

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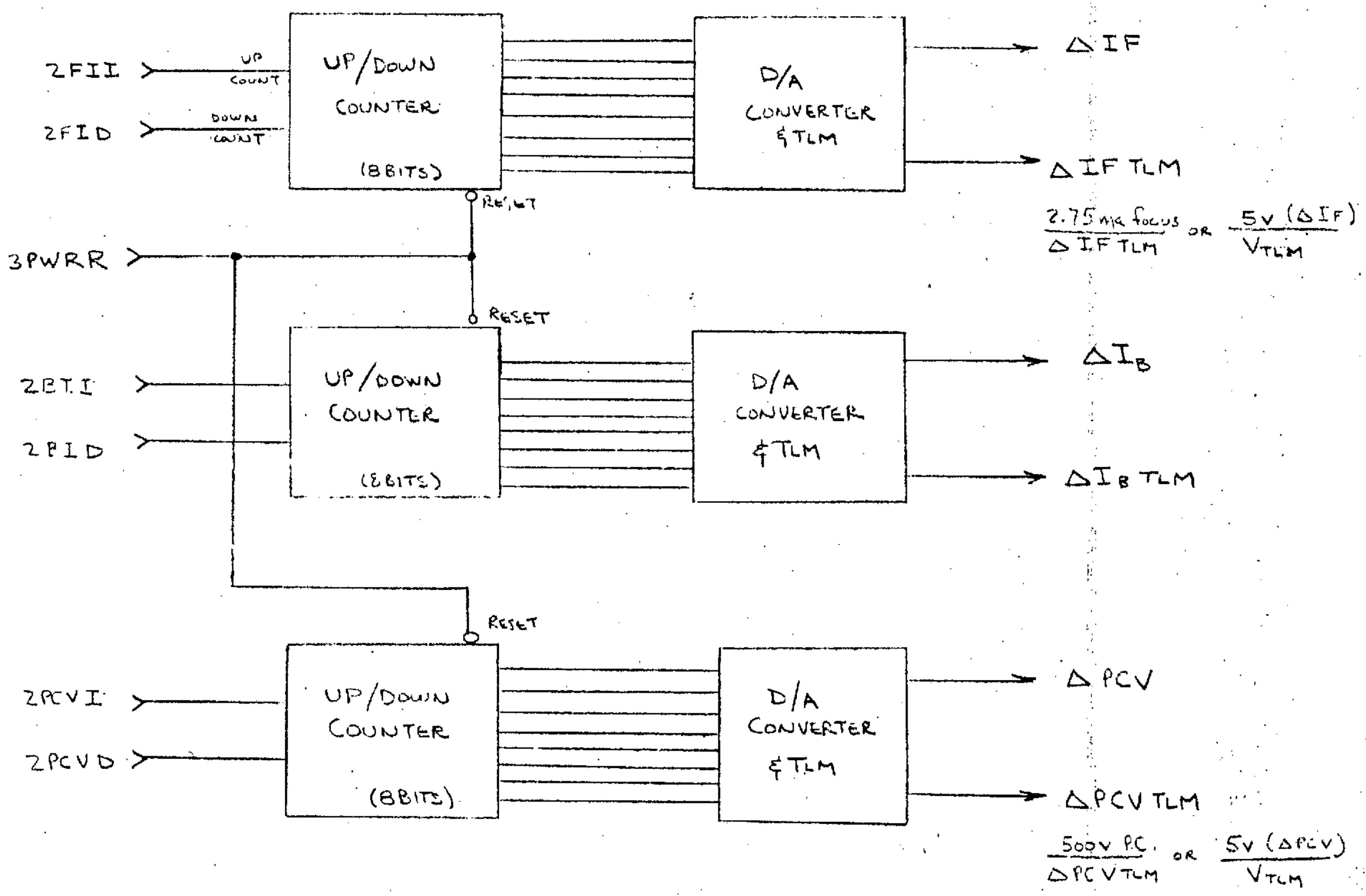
TELEMETRY

12/8/72

BLOCK DIAGRAM



DELTA GENERATORS

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12/8/72

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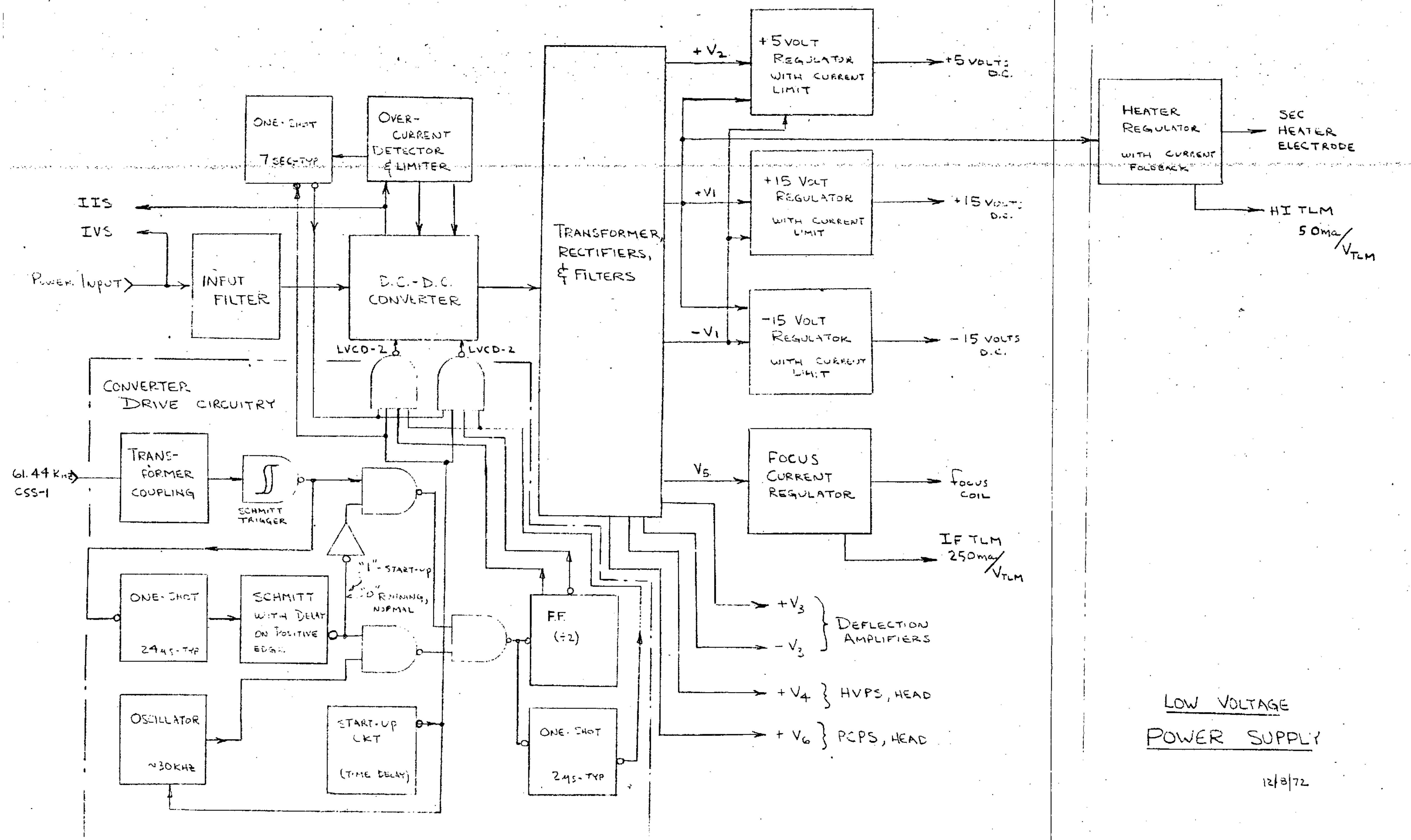


LOW VOLTAGE POWER SUPPLY

12/8/72

Table I, Camera Sequence Truth Table

MODES	BEAM	HEATER	PHOTO-CATHODE	SCAN SIZE	SCAN RATE	TARGET	MESH	ERASE LIGHTS
Prepare I		ON 2 MIN. PRIOR-						
FRAMES								
0-4	1	1	1	+	1	O	1	1
5	1	1	O	+	1	O	1	O
6	1	1	O	1	1	O	1	O
7	O	1	O	1	1	1	+	O
8-11	1	1	O	1	1	1	+	O
Return To Hold	O	OPTIONAL	O	O	1	1	1	O
Prepare II		ON 2 MIN. PRIOR-						
FRAMES								
0-4	+	1	1	+	+	O	1	+
5	+	1	O	+	+	O	1	O
6	+	1	O	1	+	O	1	O
7-14	O	1	O	1	+	1	+	O
15-17	+	1	O	1	+	1	+	O
18	1	1	O	1	1	1	+	O
Return To Hold	O	OPTIONAL	O	O	1	1	1	O
Exposure	O	OPTIONAL	1	O	1	1	O	O
Hold	O	OPTIONAL	O	O	1	1	1	1
Ready	O	ON 2 MIN. PRIOR- 1	O	1	1	+	+	O
Readout (Requires 10 sec. of Ready prior to Readout)	1	1	O	1	1	+	+	O
Continuous Scan Low	1	ON 2 MIN. PRIOR- 1	1	1	1	1	1	O
Continuous Scan High	1	ON 2 MIN. PRIOR- 1	1	1	1	1	+	O
Fast Cont. Scan Low	+	ON 2 MIN. PRIOR - 1	1	+	+	1	1	O
Fast Cont. Scan High	+	ON 2 MIN. PRIOR - 1	1	+	+	1	+	O

FOLDOUT FRAME

FOLDOUT FRAME

TABLE 2. CODES FOR CAMERA SEQUENCE

FUNCTION	CODES 0	1	+
BEAM	OFF	ON	HI
HEATER	OFF	ON	—
PHOTO-CATHODE	OFF	ON	—
SCAN SIZE	ZERO	NORMAL	OVER
SCAN RATE	—	NORMAL (12.5 sec/FRAME, 60 L/s)	FAST (16 FOLDS FASTER)
TARGET	PREPARE	NORMAL	PULSED (READOUT)
MESH	ZERO	LOW	HIGH
ERASE LIGHTS	OFF	ON	ON-HIGH

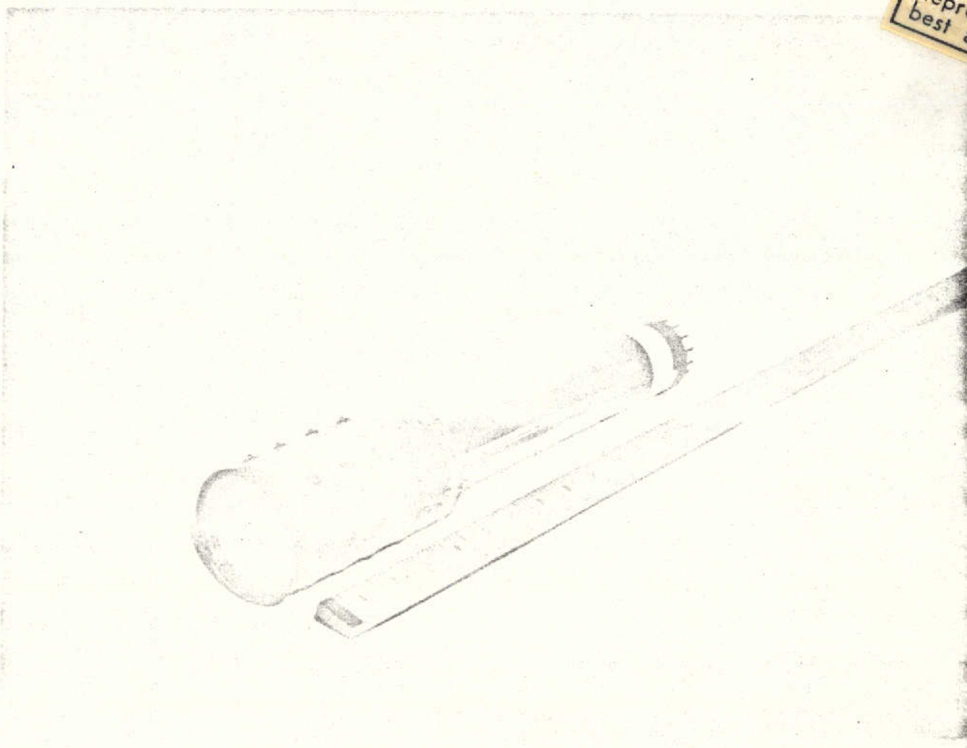


FIG. I
SEC VIDICON

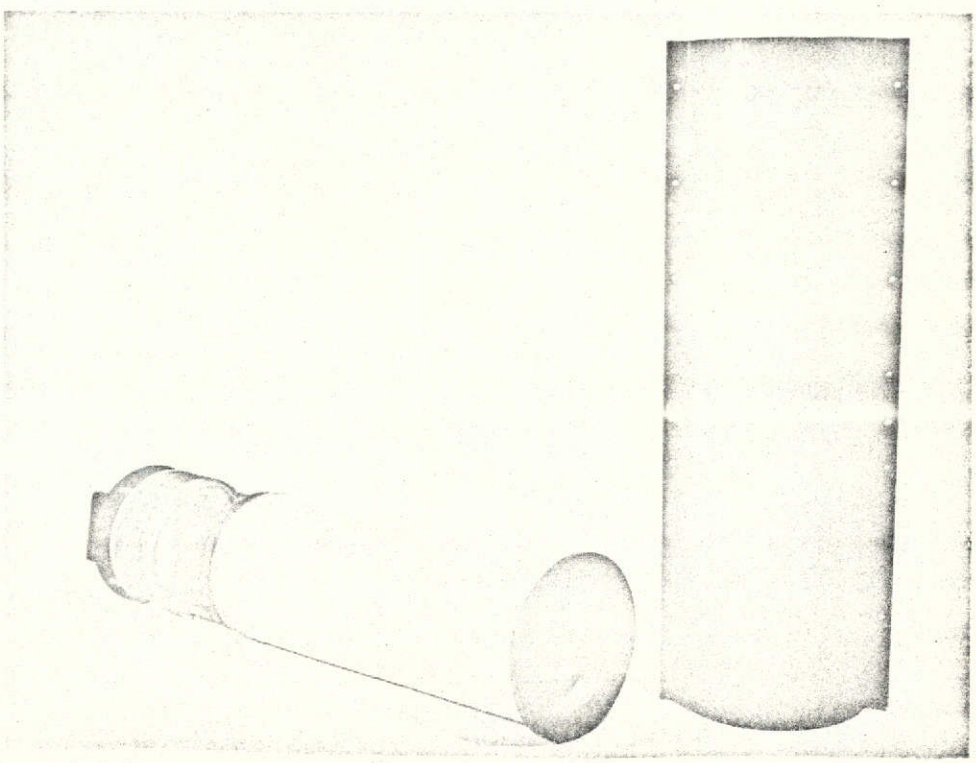


FIG. 2
HEAD ELECTRONICS & HEAD HOUSING

FIG. 3
ASSEMBLED CAMERA HEAD

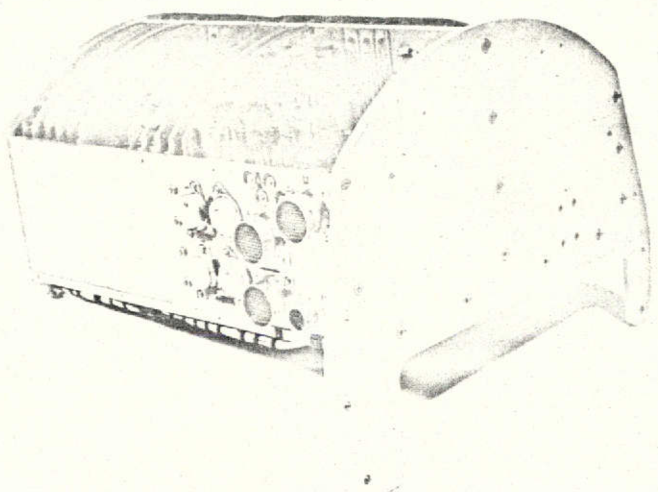


FIG. 4
CAMERA ELECTRONICS

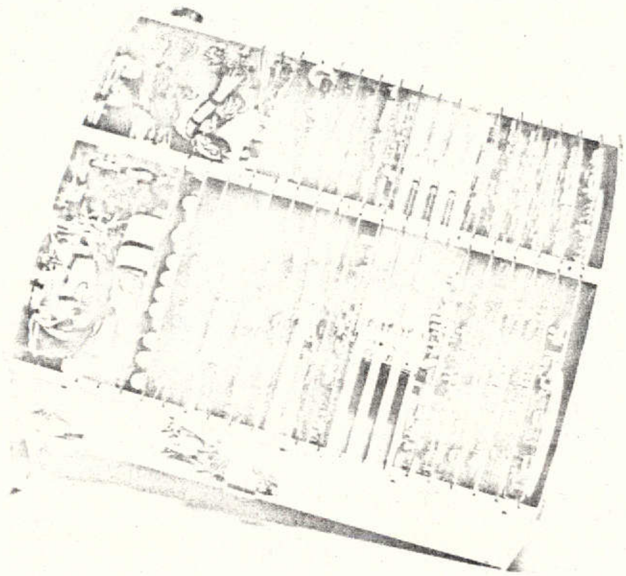


FIG. 5
CAMERA ELECTRONICS

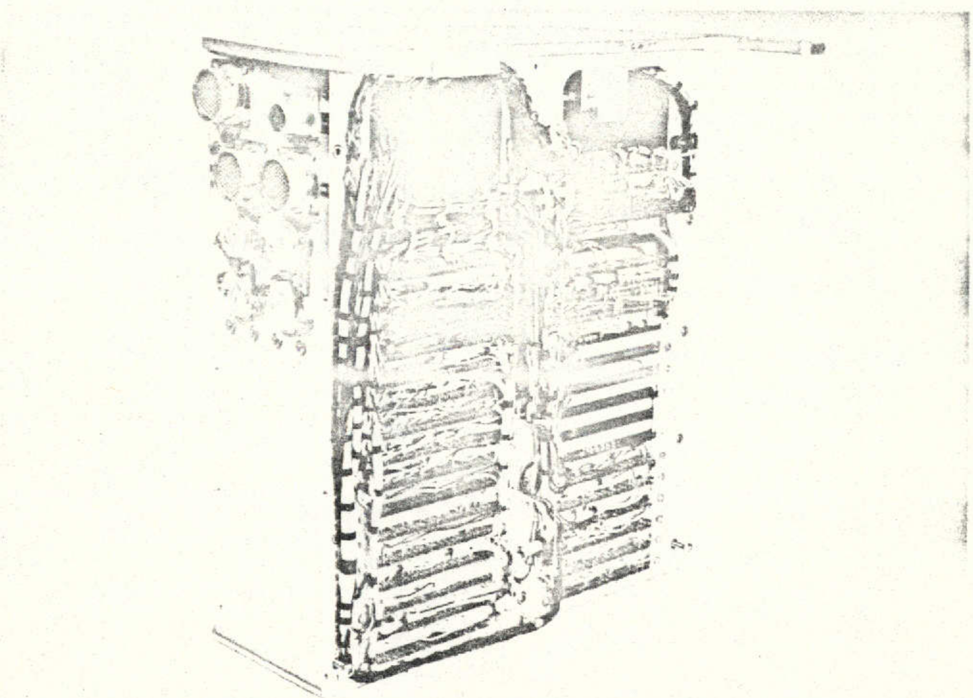
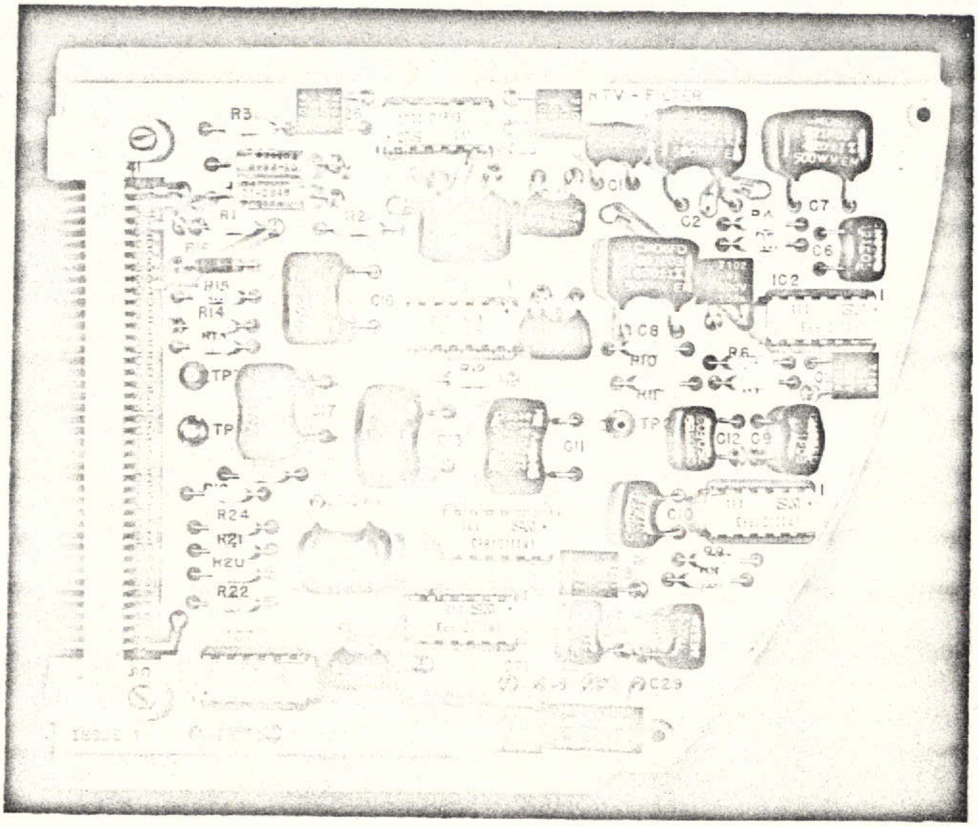


FIG. 6
CAMERA ELECTRONICS



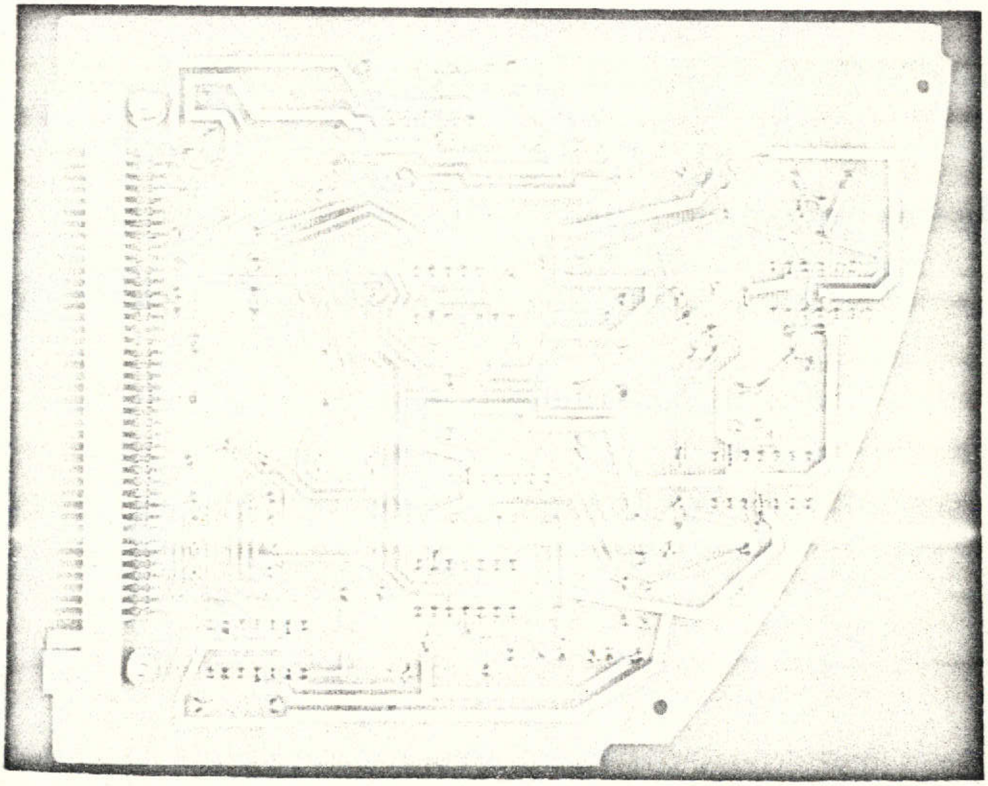
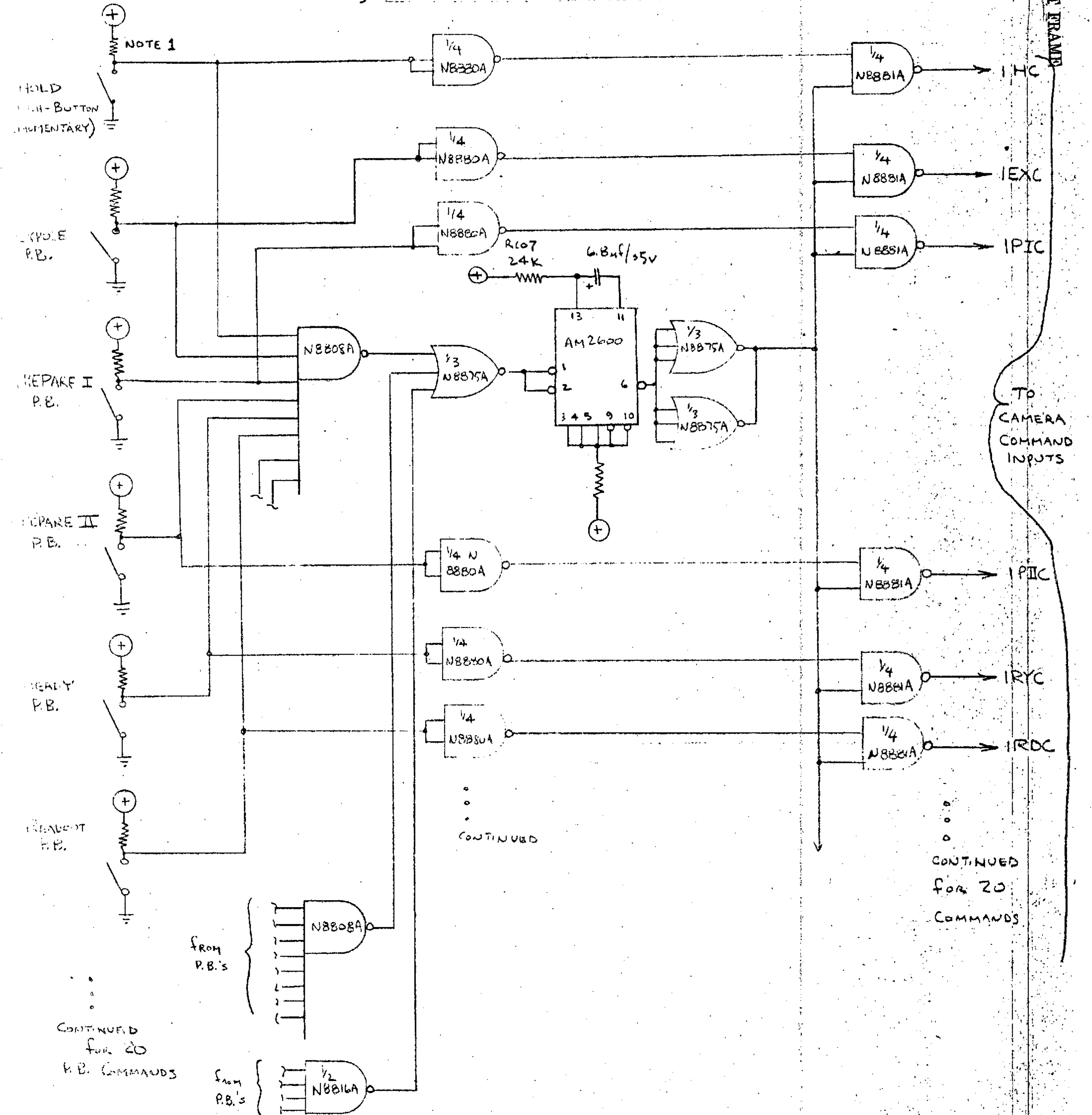


FIG. 7
STV PRINTED CIRCUIT BOARD, VIDEO FILTER

FIGURE 8, TEST CONSOLE COMMAND CIRCUITRY



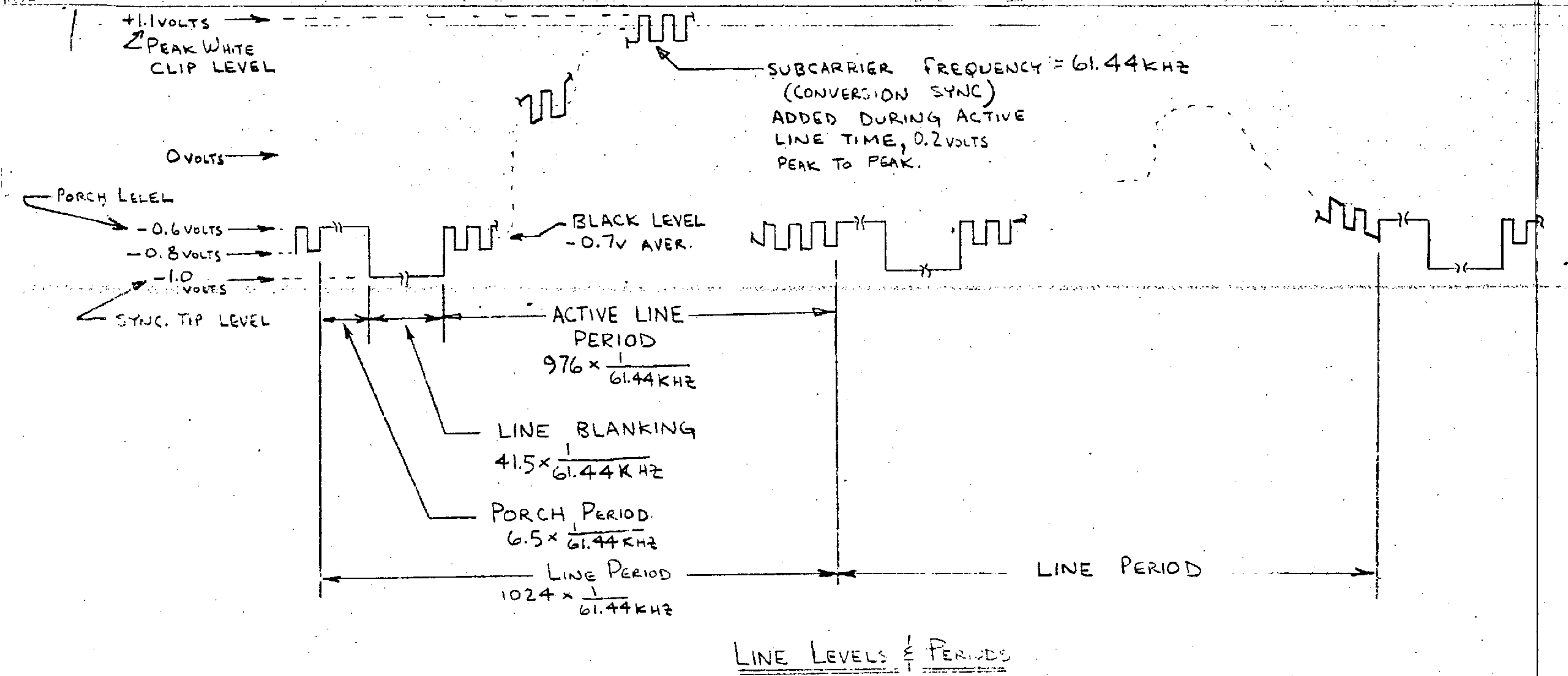
NOTES:

1. ALL RESISTORS ARE 2K Ω, RC07 UNLESS OTHERWISE NOTED.

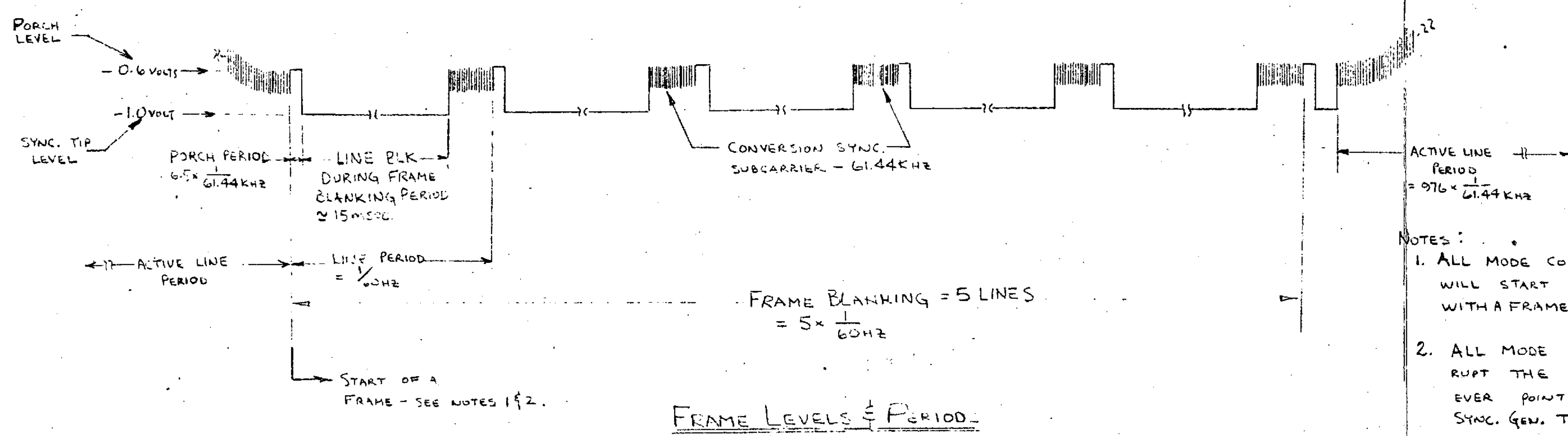
FOLDOUT FRAME

FIGURE 9

VIDEO WAVESHAPE & TIMING



LINE LEVELS & PERIODS



FRAME LEVELS & PERIOD

NOTES:

1. ALL MODE COMMANDS WILL START THE SYNC. GENERATOR WITH A FRAME BLANKING PERIOD.

2. ALL MODE COMMANDS WILL INTERRUPT THE SYNC. GEN. AT WHATEVER POINT IT'S AT, AND RESET THE SYNC. GEN. TO FRAME BLANKING.

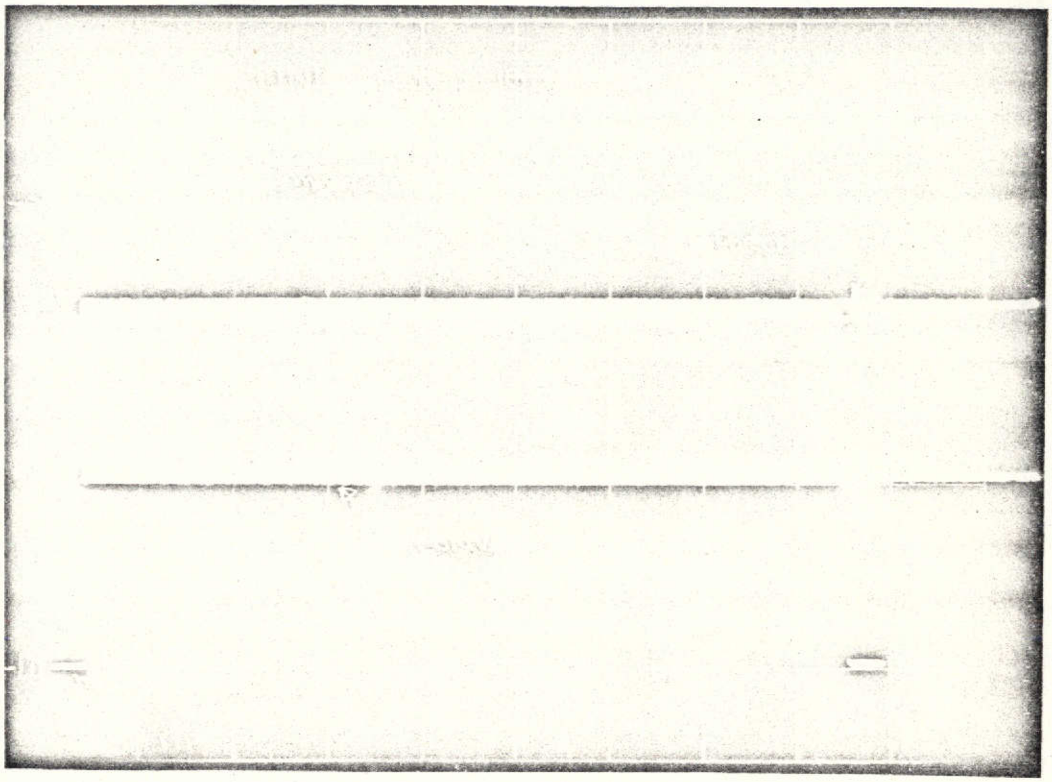


FIG. 10
SINGLE VIDEO LINE, BLACK LEVEL, WITH CONVERSION SYNC.

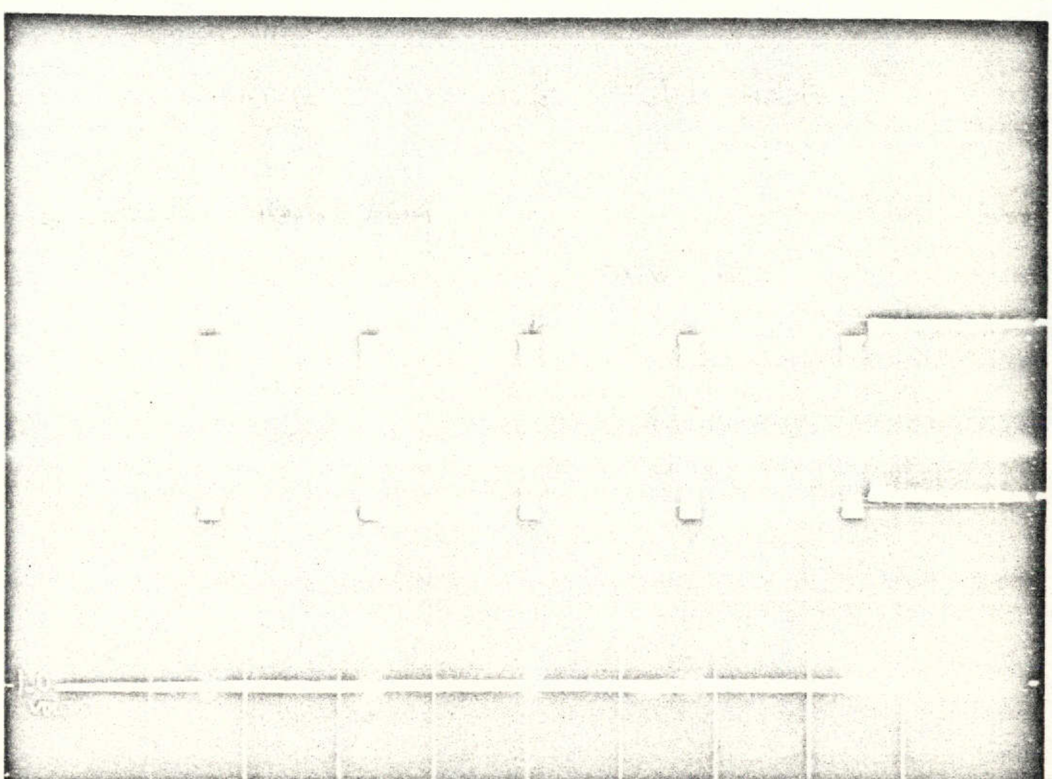


FIG. 11
FRAME BLANKING VIDEO WITH CONVERSION SYNC.

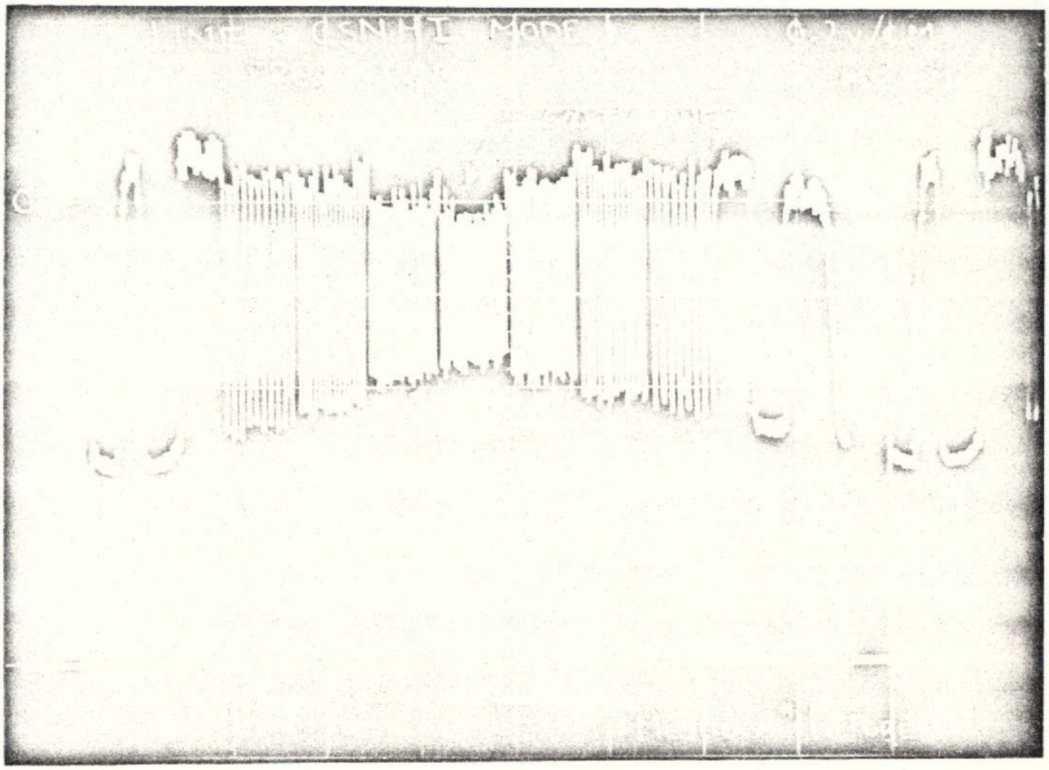


FIG. 12
SINGLE VIDEO LINE OF A FREQUENCY CHART
WITHOUT CONVERSION SYNC.

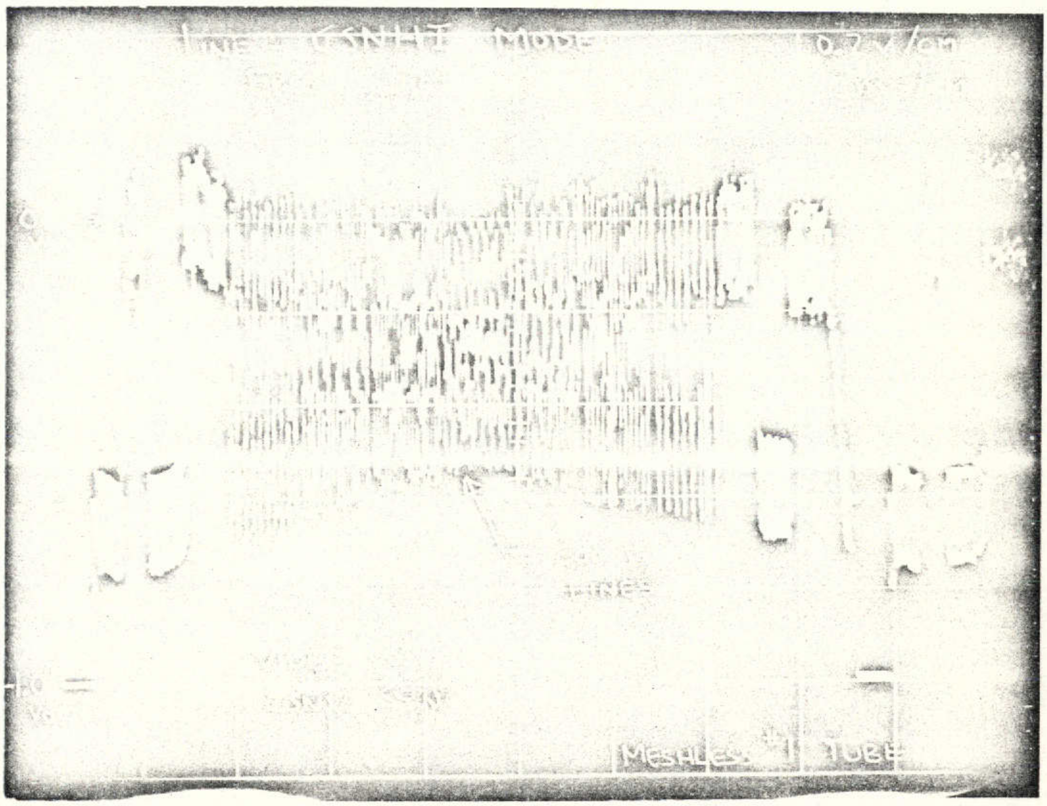


FIG. 13
SINGLE VIDEO LINE OF A FREQUENCY CHART
WITH CONVERSION SYNC.

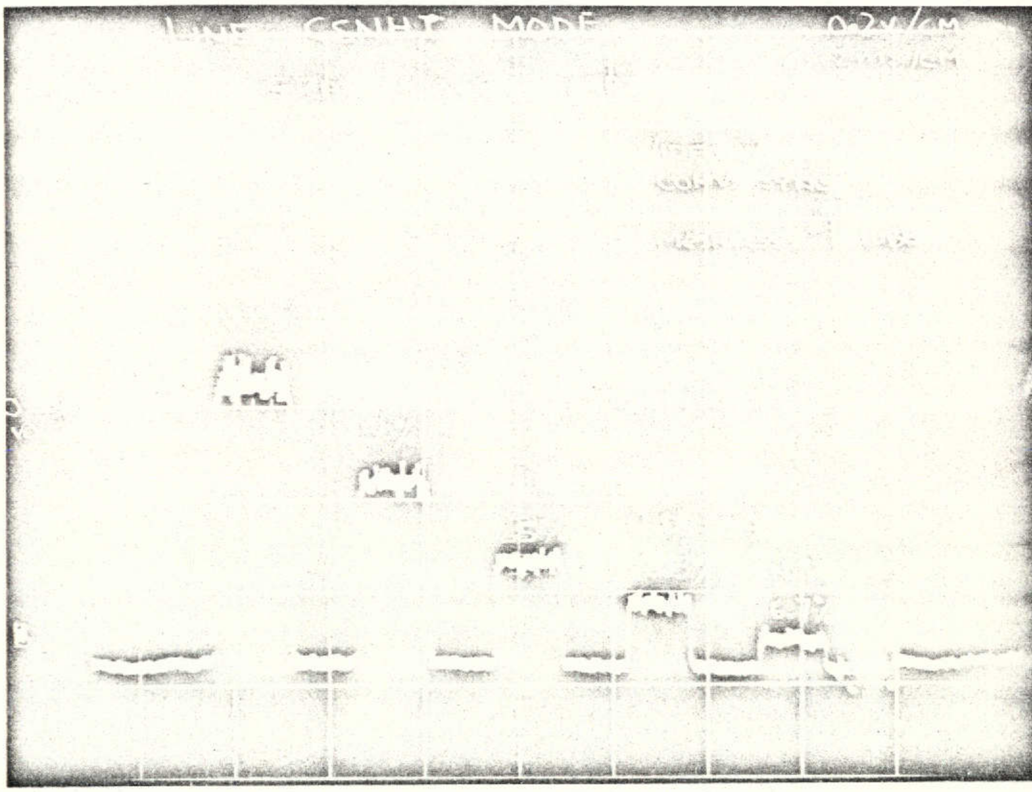


FIG. 14
SINGLE VIDEO LINE OF A GRAY SCALE CHART
WITHOUT CONVERSION SYNC.

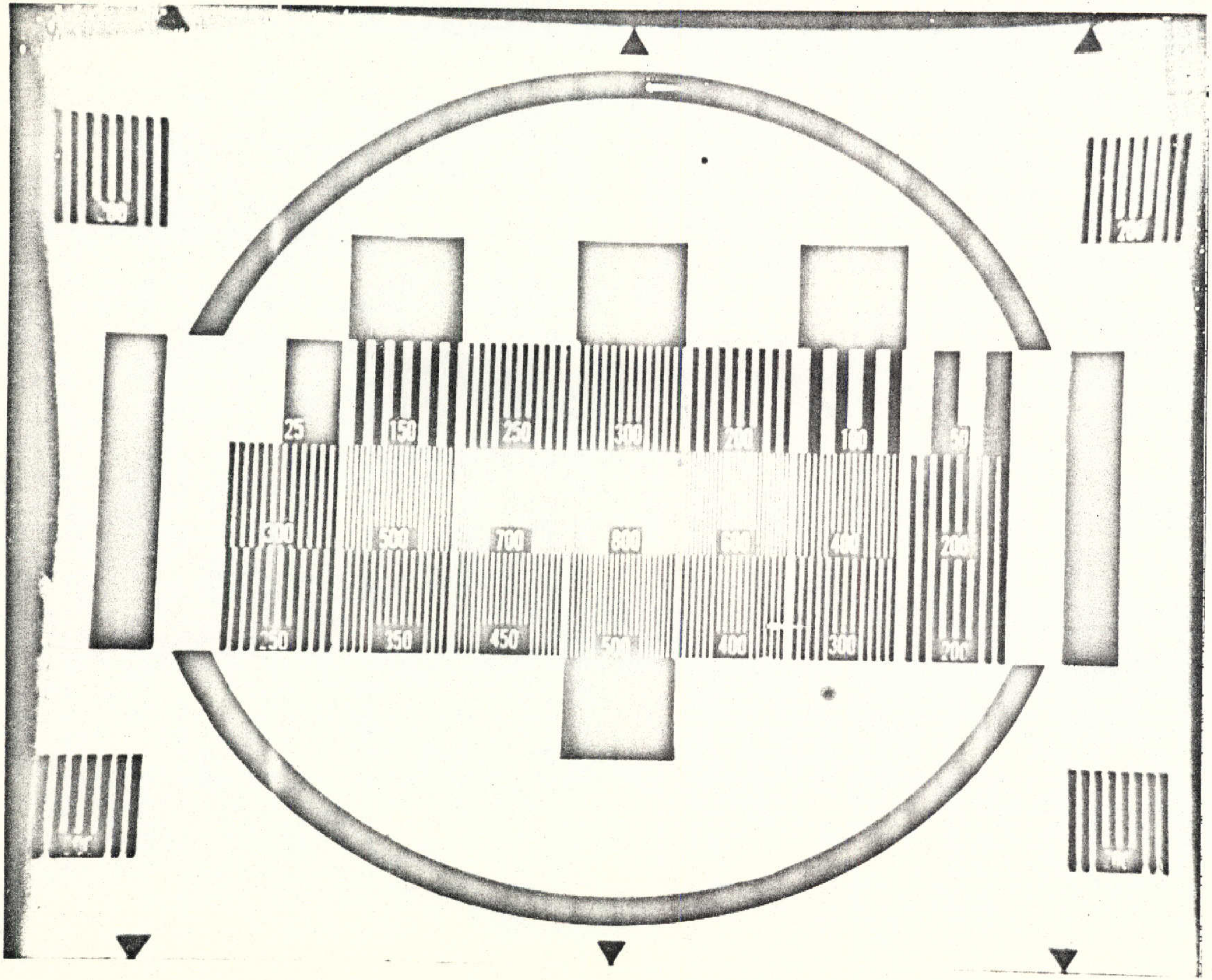


FIG. 15
DIGITIZED FREQUENCY CHART

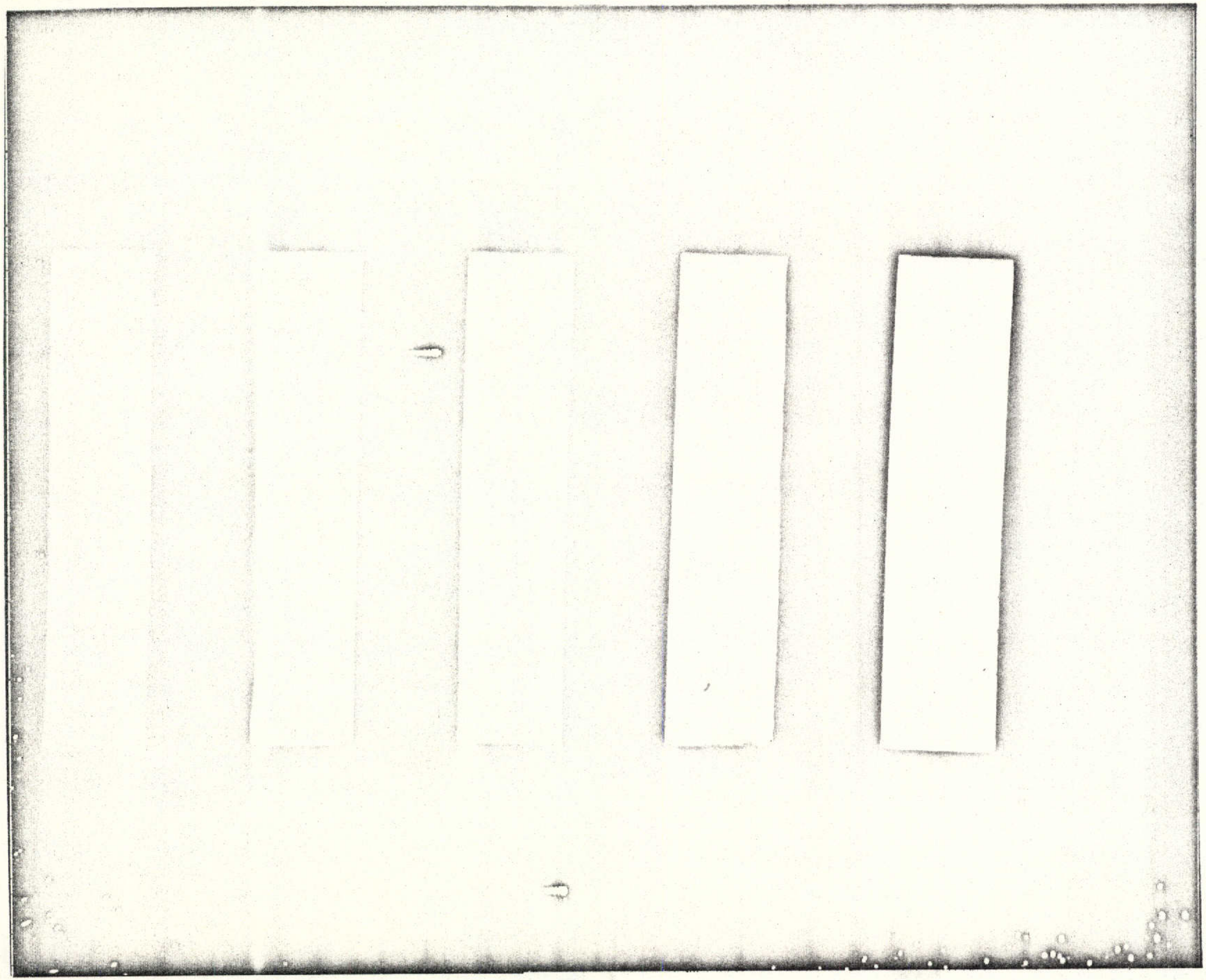


FIG. 16
DIGITIZED GRAY SCALE

APPENDIX A

BLOCK DIAGRAM GLOSSARY

H	Hold
Ex	Expose
PI	Prepare I
PII	Prepare II
P	Prepare I or Prepare II
RY	Ready
RYT	Ready Timer
RD	Read
ET	Exposure Test
CSN	Continuous Scan
CSNHI	Continuous Scan, HI Mesh
FCSN	Fast Continuous Scan
FCSNHI	Fast Continuous Scan, HI Mesh
ARMHI	Arm HI Mesh
HØN	Heater On
HØFF	Heater Off
HSD	Heater Shut-Down
FI	Focus Current
BI	Beam Current
PCV	Photocathode Voltage
FII	Focus Current Increment
FID	Focus Current Decrement
XI	X Increment
XD	X Decrement
HC	Hold Command
XC	X Command
HPB	Hold Pushbutton
XPB	X Pushbutton
HILT	Hi-Mesh Latch Timer
HIL	Hi Mesh Latch

APBR	Any Pushbutton Reset
APBRP	Any Pushbutton Reset Processed
XP	X Processed
PWRR	Power Reset
MFR	Malfunction Reset
HØ	Heater Qualified
HI/FCSNR	HI Latch and Fast Cont. Scan Latch Reset
F12	Frame 12
FX	Frame X
FA	Single Frame Pulse
FO-4	Frame 0 to Frame 4
FX-Y	Frame X to Frame Y
HLD	Hold Lamp Driver
XLD	X Lamp Driver
TVR	Target Voltage Read
TVP	Target Voltage Prepare
TVN	Target Voltage Normal
PC	Photocathode
EL	Erase Lamps
ELHI	Erase Lamps HI
SSØ	Scan Size Over
SSN	Scan Size Normal
SSZØ	Scan Size Zero
FSN	Fast Scan
MLØ	Mesh Low
MLØP	Mesh Low Processed
MZØ	Mesh Zero
MHI	Mesh HI
BØ	Beam On
BØHI	Beam On HI
CCS	Continuous Conversion Sync.
CCS I	Cont. Conversion Sync Inhibit

PE	Preset Everything
PEL	Preset Everything Leading
LS	Line Sync
LD	Line Drive
FS	Frame Sync
FD	Frame Drive
CS	Conversion Sync
LCS	Live Conversion Sync
LX	Live X
LMB	Live Mixed Blanking
CS/NCLD	Conversion Sync for Number of Conversions per Line Drive
LS/NLFD	Line Sync for Number of Lines per Frame Drive
PCCV	Photocathode Control Voltage
PCDY	Photocathode Delay
PCPSDR	Photocathode Power Supply Drive
VT	Target Voltage
ETB	Exposure Test Blanking
MCB	Mixed Cathode Blanking
SI	Sweep Inhibit
VF	Video Frame
VFB	Video Frame Blanking
VMB	Video Mixed Blanking
LVMB	Live Video Mixed Blanking
LVCS	Live Video Conversion Sync
LVCSI	Live Video Conversion Sync Inhibit
EDR	Electrode Divider Return
Δ IB	Beam Current Delta
IBVΔ	Beam Current Delta Voltage
IBVN	Beam Current Normal Voltage
IBVHI	Beam Current HI Voltage

ELITLM	Erase Lamp Current Telemetry
FIS	Frame Current Sample
FITLM	Frame Current Telemetry
LIS	Line Current Sample
LITLM	Line Current Telemetry
MVS	Mesh Voltage Sample
MVTLM	Mesh Voltage Telemetry
IBS	Beam Current Sample
IBTLM	Beam Current Telemetry
IVS	Input Voltage Sample
IVTLM	Input Voltage Telemetry
IIS	Input Current Sample
IITLM	Input Current Telemetry
PATTLM	Pre-Amp Temperature Telemetry
ETTLM	Electronics Temperature Telemetry
PCTTLM	Photocathode Temperature Telemetry
PCITLM	Photocathode Power Supply Telemetry
STLM	Status Telemetry
STB4	Status Telemetry BIT 4
STBX	Status Telemetry BIT X
PU	Pulse Comm. for STLM
IFTLM	Focus Current Telemetry
HITLM	Heater Current Telemetry
Δ IF	Focus Current Delta
Δ IFTLM	Focus Current Delta Telemetry
Δ PCV	Photocathodes Voltage Delta
Δ PCVTLM	Photocathode Voltage Delta Telemetry
Δ IBTLM	Beam Current Delta Telemetry
LVCD	Low Voltage Converter Drive

APPENDIX B

Stratoscope Integrating Television Camera

Interface Specification and Ground Station Requirements
Drawing Number, 209-A-093

Section	Topic
1	Display and Recording
2	Commands (up)
3	Telemetry (down)
4	Main Data Channel (down)
5	Input Power Supply

Section 1 - Display and Recording

The ground processing of the Main Data Channel (the integrating television signal) is shown on Drawing 209-C-092, Rev. 1 and the specifications of the Main Data Channel are covered in Section 4.

The major display and recording units required are:

1. Two oscilloscopes (two requested primarily to insure reliability via redundancy) suitable for examining the video and sync signals. A Tektronix R 561B with 3A6 amplifier 3B3 time base and P6006 and 6028 probes is a suitable oscilloscope system.
2. One visual slow scan monitor for viewing the live and taped television images. A Conrac CSS-5 with 14" P7 phosphor per Princeton University purchase order No. B-14128 is a suitable visual monitor.
3. One photographic slow scan monitor equipped to make Polaroid photographs. A Conrac CSS-5 with a Polaroid camera compatible CRT would do. The phosphor should be P7 so that the photographic monitor could be used as a backup for the visual monitor as a reliability measure.

4. Two instrumentation tape recorders (two requested primarily to insure reliability via redundancy) fully compatible with the baseband video and sync signals. The recorder performance requirements are severe, especially time base stability and signal to noise ratio. Honeywell 5600 system with 60 ips double extended fm electronics for two channels is a suitable tape recorder.

5. A Polaroid oscilloscope camera for use with the video signal oscilloscope. To aid system flexibility and reliability it should be interchangeable with the photographic monitor camera.

Section 2 - Commands (up)

To control the integrating TV camera approximately 20 monetary contact closure type commands must be transmitted to the camera in flight. Only one command should be sent at a time. Approximately one second response time is adequate. The contact closure duration should be between 20 millisec. and 100 millisec (50 millisec. nominal) for each command.

Other commands to control the optical shutter ahead of the TV camera are also required. (The shutter is not considered part of the TV camera).

TV Camera Commands

1. Hold
2. Expose
3. Prepare I
4. Prepare II
5. Ready
6. Readout
7. Continuous Scan
8. Continuous Scan, Hi Mesh
9. Arm Hi Mesh Modes
10. Exposure test
11. Heater ON
12. Heater OFF
13. Focus I increment
14. Focus I decrement
15. Beam I increment
16. Beam I decrement
17. Fast Continuous Scan
18. Fast Continuous Scan with Mesh High
19. Photocathode V increment
20. Photocathode V decrement

Section 3 - Telemetry (down)

Approximately 21 narrowband telemetry channels to monitor the integrating TV camera and to provide command and adjustment verification are needed. The signals are 0 to +5 volt dc with maximum allowed channel noise and required bandwidth as shown in the following list. All channels are dc coupled and dc errors are inclued in the noise limits.

Channel	Maximum Noise (mv_{pp})	Minimum Bandwidth (Hz)
1. Focus Current	5	1
2. Beam Current	50	100
3. Heater Current	50	1
4. Erase Lamp Current	500	1
5. V Target	5	1
6. Frame Scan Current	50	100
7. Line Scan Current	50	100
8. Input Current	50	1
9. Input Voltage	50	1
10. PC HVPS Current	50	100
11. Sequence Status	50	10
12. Mesh Voltage	5	1
13. PC Voltage Delta	50	1
14. PC Control Voltage	5	100
15. Focus Current Delta	50	1
16. Beam Current Delta	50	1
17. PC Temperature	50	1
18. Preamp Temperature	50	1
19. Electronics Box Temperature	50	1
20. Spare	50	1
21. Spare	50	1

Section 4 - Main Data Channel (down)

The ultimate scientific success of the flight depends entirely on the data returned via the Main Data Channel. It carries the intensity and address information of the image elements. The electrical characteristics required are as follows:

Amplitude and frequency: +1.1 to -1.0 volts, dc to 100 kHz.

Amplitude vs. frequency: ±0.1db dc to 70 kHz. +1 to -3 db 70 to 100 kHz.

Peak to Peak differential time delay (phase response) dc to 70 kHz: 3 microseconds

Time base stability over any 20 millisecond interval: ± 4 microseconds

Channel noise (all sources including dc drifts) dc to 100 kHz: less than 5 millivolts peak to peak

Video Waveform: Figure 1 (page B6).

Video Termination Resistance = 100 ohms.

Section 5 - Input Power Supply

The STV Camera shall be supplied with +28.0 ±4.0 volts dc. The current required will be about 7 amperes.